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E. Friedmann

PRESIDENT 1911

TRANSACTIONS

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

Published by the Society
Publication Office, No. 154 Nassau Street
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E. Friedmann

PRESIDENT 1911

TRANSACTIONS

OF

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OFFICERS

OF

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

1910-1911

PRESIDENT

EDWARD N. FRIEDMANN.....New York, N. Y.

VICE-PRESIDENTS

CHARLES E. LUCKE.....New York, N. Y.

Term expired at Annual Meeting of 1911

ALBERT RUEMMELI.....St. Louis, Mo.

Term expires at Annual Meeting of 1912

DIRECTORS

MADISON COOPER.....Watertown, N. Y.
N. H. HILLER.....Carbondale, Pa.
W. H. MANNS.....Waynesboro, Pa.

Terms expired at Annual Meeting of 1911

CARL BEHN.....New York, N. Y.
CHARLES DICKERMAN.....Philadelphia, Pa.
GARDNER T. VOORHEES.....New York, N. Y.

Terms expire at Annual Meeting of 1912

LOUIS BLOCK.....New York, N. Y.
LOUIS DOELLING.....New York, N. Y.
THOMAS SHIPLEY.....York, Pa.

Terms expire at Annual Meeting of 1913

TREASURER

WALTER C. REID.....New York, N. Y.

SECRETARY

WILLIAM H. ROSS.....New York, N. Y.

PAST AND PRESENT OFFICERS

PRESIDENTS.

John E. Starr—1905 ..... New York, N. Y.
W. Everett Parsons—1906 ..... Newark, N. J.
D. S. Jacobus—1907 ..... Hoboken, N. J.
Edgar Penney—1908 ..... Newburgh, N. Y.
Louis Block—1909 ..... New York, N. Y.
Roderick H. Tait—1910 ..... St. Louis, Mo.
Edward N. Friedmann—1911 ..... New York, N. Y.

VICE-PRESIDENTS.

H. B. Roelker—1905 ..... New York, N. Y
P. De C. Ball—1905-1906 ..... St. Louis, Mo.
John E. Starr—1906-1907 ..... New York, N. Y.
James Wills[1]—1907-1908 ..... New York, N. Y.
Karl E. Vesterdahl—1908-1909 ..... New York, N. Y.
Homer McDaniel—1909-1910 ..... Cleveland, Ohio
Chares E. Lucke—1910-1911 ..... New York, N. Y.
Albert Ruemmeli—1911-1912 ..... St. Louis, Mo.

TREASURER.

Walter C. Reid—1905-1911 ..... New York, N. Y.

SECRETARY.

William H. Ross—1905-1911 ..... New York, N. Y.

DIRECTORS.

Louis Block—1905-1908 and 1911-1913 ..... New York, N. Y.
W. Everett Parsons—1905 ..... Newark, N. J.
Edgar Penney—1905-1907 ..... Newburgh, N. Y.
D. S. Jacobus—1905-1906 ..... Hoboken, N. J.
E. L. Phillips—1905-1906 ..... New York, N. Y.
W. T. Robinson—1905-1906 ..... Philadelphia, Pa.
L. Howard Jenks—1905-1907 ..... New York, N. Y.
Thomas Shipley—1905-1913 ..... York, Pa.
Henry Torrance, Jr.—1905-1907 ..... New York, N. Y.
H. B. Roelker—1906-1908 ..... New York, N. Y.
J. J. de Kinder—1907-1909 ..... Philadelphia, Pa.
F. W. Pilsbry—1907-1909 ..... Chicago, Ill.
Llewellyn Williams—1907-1909 ..... Boston, Mass.
John E. Starr[2]—1908 ..... New York, N. Y.
John C. Wait—1908-1910 ..... New York, N. Y.
Karl Wegemann—1908-1910 ..... New York, N. Y.
Madison Cooper—1909-1911 ..... Watertown, N. Y.
N. H. Hiller—1909-1911 ..... Carbondale, Pa.
W. H. Manns—1909-1911 ..... Waynesboro, Pa.
Charles Dickerman—1910-1912 ..... Philadelphia, Pa.
Edward N. Friedmann—1910 ..... New York, N. Y.
Gardner T. Voorhees—1910-1912 ..... New York, N. Y.
Carl Behn[3]—1911-1912 ..... New York, N. Y.
Louis Doelling—1911-1913 ..... New York, N. Y.

[1] Deceased. [2] Filled the unexpired term of Edgar Penney.
[3] Filled the unexpired term of Edward N. Friedmann.

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.

CONSTITUTION.

NAME, OBJECT AND GOVERNMENT.

C 1. The title of this Society shall be "The American Society of Refrigerating Engineers."

C 2. The object of this Society is to promote the Arts and Sciences connected with Refrigerating Engineering.

C 3. The principal means for this purpose shall be the holding of meetings for the reading and discussion of appropriate papers, and for social intercourse; the publication and distribution of its papers and discussions; and the maintenance of a library of data on refrigeration.

C 4. The Society shall be governed by this Constitution, and by By-Laws and Rules in harmony therewith.

C 5. The Society shall be organized as a Corporation under the Laws of the State of New York.

MEMBERSHIP.

C 6. Persons connected with the Arts and Sciences relating to Refrigerating Engineering may be eligible for admission into the Society.

C 7. The membership of the Society shall consist of Members, Associates and Juniors. Members and Associates are entitled to vote and to hold office. Juniors shall not be entitled to vote nor to be officers of the Society, but shall be entitled to the other privileges of membership.

C 8. Members and Associates are entitled to vote on all questions before any meeting of the Society in person, or by proxy given to a voting member in writing. A proxy shall not be valid for a greater time than six months.

C 9. A Member shall be twenty-six years of age or over. He must have been so connected with Refrigerating Engineering as to be competent as a designer or as a constructor, to take responsible charge of work in his branch of Refrigerating Engineering, or he must have served as a teacher of Refrigerating Engineering for more than five years.

C 10. An Associate shall be twenty-six years of age or over and shall be so connected with Refrigerating Engineering as to be competent to take charge of engineering work, or to co-operate with Refrigerating Engineers.

C 11. A Junior shall be twenty-one years of age or over. He must have had such Refrigerating Engineering experience as will enable him to fill a responsible subordinate position in Refrigerating Engineering work, or he must be a graduate of an engineering school.

C 12. The rights and privileges of every Member, Associate and Junior shall be personal to himself, and shall not be transferable or transmissible by his own act or by operation of law.

ADMISSION.

C 13. All applications for membership as Member, Associate or Junior shall be presented to the Council, which shall consider and act upon each application, assigning each approved applicant to the classification to which, in the judgment of the Council, he is entitled. The name of each candidate thus approved by the Council shall, unless objection is made by the applicant, be submitted to the voting membership for election by means of a letter ballot.

C 14. Associates or Juniors desiring to change their grade of membership shall make application to the Council in the same manner as is required in the case of a new applicant.

C 15. Election to membership shall be by a sealed letter ballot as the By-Laws shall provide. Adverse votes to the number of four per cent. of the votes cast shall be required to defeat the election of an applicant.

C 16. Each person elected shall subscribe to this Constitution, and shall pay the initiation fee before he can be entitled to the rights and privileges of membership. If such person does not comply with these requirements within six months after notice of his election, he will be deemed to have declined election. The Council may, thereupon, declare his election void.

INITIATION FEES AND DUES.

C 17. The initiation fee for membership shall be as follows:

For Members and Associates, five dollars.

For Juniors, five dollars. A Junior, on promotion to any other grade of membership, shall pay an additional fee of five dollars.

The annual dues for membership shall be as follows:

For Members and Associates, ten dollars.

For Juniors, five dollars for the first six years of their membership, and thereafter the same as for a Member or Associate.

SUSPENSIONS AND EXPULSIONS.

C 18. Any Member, Associate or Junior who shall leave his annual dues unpaid for two years shall, at the discretion of the Council, have his name stricken from the roll of membership and shall cease to have any further rights of membership.

C 19. The Council may refuse to receive the dues of any Member, Associate or Junior who shall have been adjudged by the Council to have violated the Constitution or By-Laws of the Society, or who, in the opinion of the Council, expressed by a two-thirds vote of the entire Council, shall have been guilty of conduct rendering him unfit to continue in its membership; and the Council may expel such person and remove his name from the list of members.

THE COUNCIL.

C 20. The affairs of the Society shall be managed by a Board of Directors chosen from among its Members and Associates, which shall be styled "The Council." The Council shall consist of the President of the Society, who shall be the presiding officer; the two Vice-Presidents, Treasurer and nine Members or Associates. Seven Members of the Council shall constitute a

quorum for the transaction of business. The Secretary may take part in the deliberations of the Council, but shall not have a vote therein.

C 21. The Council thus constituted shall regulate its own proceedings and shall be the legal Trustee of the Society. All gifts or bequests not designated for a specific purpose shall be invested by the Council and only the income therefrom may be used for current expenses.

C 22. Should a vacancy occur in the Council, or in any elective office except the presidency, through death, resignation or other cause, the Council may elect a Member or Associate to fill the vacancy until the next annual election.

C 23. The Council shall present at the Annual Meeting of the Society a report verified by the President or Treasurer or by a majority of the members of the Council, showing the whole amount of real and personal property owned by the Society, where located, and where and how invested, and the amount and nature of the property acquired during the year immediately preceding the date of the report, and the manner of the acquisition; the amount applied, appropriated or expended during the year immediately preceding such date, and the purposes, objects or persons to or for which such applications, appropriations or expenditures have been made; also the names and places of residence of the persons who have been admitted to membership in the Society during the last year, which report shall be filed with the records of the Society, and an abstract thereof shall be entered in the minutes of the proceedings of the Annual Meeting.

C 24. An act of the Council which shall have received the expressed or the implied sanction of the membership at the next subsequent meeting of the Society shall be deemed to be the act of the Society, and shall not afterward be impeached by any member.

C 25. The Council may, by a two-thirds vote of the members present, declare any elective office vacant, on the failure of its incumbent for one year, from inability or otherwise, to attend the Council meetings, or to perform the duties of his office, and shall thereupon appoint a Member or Associate to fill the vacancy until the next Annual Meeting. The said appointment shall not render the appointee ineligible to election to any office.

OFFICERS.

C 26. At each Annual Meeting there shall be elected from among the Members and Associates:

A President to hold office for one year.

Two Vice-Presidents, one to hold office for one year, and one to hold office for two years. After the first year one Vice-President to be elected annually for a term of two years.

A Treasurer to hold office for one year.

Nine Members or Associates shall be elected to the Council at the first Annual Meeting, three to hold office for one year, three to hold office for two years, and three to hold office for three years, and at each subsequent Annual Meeting three Members or Associates shall be elected, each to serve three years.

C 27. The election of officers shall be by ballot, as the By-Laws shall provide.

C 28. The term of all elective officers shall begin on the adjournment of the Annual Meeting of the Society. Officers shall continue in their respective offices until their successors have been installed.

C 29. A President or Vice-President shall not be eligible for immediate re-election to the same office at the expiration of the term for which he was elected.

C 30. The Council, at its first meeting after the Annual Meeting of the Society, shall appoint a Member or Associate to serve as Secretary of the Society subject to the pleasure of the Council. The Secretary shall receive a salary which shall be fixed by the Council at the time of his appointment.

C 31. The President, Secretary and Treasurer shall perform the duties legally or customarily attaching to their respective offices under the laws of the State of New York, and such other duties as may be required of them by the Council.

C 32. A vacancy in the office of President shall be filled by the Vice-President who is senior by age.

MEETINGS.

C 33. The Society shall hold its Annual Meeting in New York City on the Monday preceding the first Tuesday in December, and such other meetings shall be held at such times and places as the Council may appoint. Twenty-five Members and Associates shall constitute a quorum for the transaction of business.

C 34. Special meetings of the Society may be called at any time at the discretion of the Council or shall be called by the President upon the written request of twenty-five members entitled to vote.

C 35. Any appropriation recommended by the Society at a meeting shall not take effect until it has been approved by the Council.

C 36. Every question which shall come before a meeting of the Society or of the Council or a Committee shall be decided by a majority of the votes cast, unless otherwise provided in this Constitution or the By-Laws, or the Laws of the State of New York. The Council may order the submission of any question to the membership for discussion by letter ballot. Any meeting of the Society at which a quorum is present may order the submission of any question to the membership for discussion by letter ballot.

STANDING COMMITTEES.

C 37. The standing committees of the Society shall be:

Finance Committee.

Publication Committee.

Membership Committee.

The members of these Committees shall be appointed by the President from members of the Council who are not officers of the Society.

TRANSACTIONS.

C 38. The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings. Matters relating to politics, religion or purely to trade shall not be discussed at a meeting of the Society, nor be included in the Transactions.

C 39. The Society shall not approve any engineering or commercial enterprise, nor allow its imprint or name to be used in any commercial work or business. No member shall describe himself in connection with the Society in any advertisement other than as a Member, Associate Member or Junior Member.

AMENDMENTS.

C 40. At annual meetings of the Society any Member or Associate may propose in writing for discussion an amendment to this Constitution. Such proposed amendment shall not be voted on at that meeting, but shall be open for discussion and such modification as may be accepted by the proposer. The proposed amendment shall be mailed by the Secretary to each Member and Associate at the time the notice of the Annual Meeting issues, and shall be voted upon at said meeting.

C 41. Such By-Laws shall be enacted as will conform with this Constitution and the Laws of the State of New York and as are required to conduct the business of the Society.

BY-LAWS.

CANDIDATES FOR MEMBERSHIP.

B 1. A candidate for admission to the Society as a Member or as an Associate must make application on a form approved by the Council, upon which he shall write a statement giving a complete account of his qualifications and engineering experience, and an agreement that he will, if elected, conform to the Constitution, By-Laws and Rules of the Society. He must refer to at least four Members or Associates to whom he is personally known.

B 2. Applications for membership from Refrigerating Engineers who are not residents in the United States or Canada and who may be so situated as not to be personally known to four Members or Associates of the Society, as required in the foregoing paragraph, may be recommended for ballot by four members of the Council, after sufficient evidence has been secured to show that in their opinion the applicant is worthy of admission to the grade which he seeks.

B 3. A candidate for admission to the Society as a Junior must make application in the same manner as provided for Members or Associates, except that he must refer to not less than three Members or Associates to whom he is personally known.

B 4. The references for each candidate for admission to the Society shall be requested to make a confidential communication to the Membership Committee, setting forth in detail such information, personally known to the referee, as shall enable the Council to arrive at a proper estimate of the eligibility of the candidate for admission to the Society.

ELECTION OF MEMBERS.

B 5. The Secretary shall mail to each member entitled to vote, at least thirty days in advance of any meeting, a ballot stating the names and the

respective grades of the candidates for membership in the Society which have been approved by the Council, and the time of the closure of voting. The voter shall prepare his ballot by crossing out the names of candidates rejected by him, and shall enclose said ballot in a sealed blank ballot envelope, which he shall then enclose in a second sealed outer envelope, on which he shall, for identification, write his name in ink. The ballot thus prepared and enclosed shall be mailed or delivered unopened to the Tellers of Election. The Secretary shall certify to the competency and the signature of all voters. On the closure of voting, the Tellers of Election shall first open and destroy the outer envelopes, and shall then canvass the ballots, and certify the result to the meeting of the Society.

B 6. The Tellers of Election shall not receive any ballot after the stated time of the closure of voting. A ballot without the endorsement of the voter written in ink on the outer envelope is defective, and shall be rejected by the Tellers of Election.

B 7. The names of those persons elected to membership, with their respective grades, shall be embodied in a written report, signed by the Tellers, and presented to the next meeting of the Society. The President shall then declare them duly elected to membership in the Society. The Tellers may, through the Secretary, in advance of any meeting, advise each candidate of the result of the canvass of the votes in his case. The names of applicants who are not elected shall neither be announced nor recorded in the Transactions.

B 8. The endorsers of an applicant who has not been elected may, with his consent, present to the Council a written request for a re-submission of his name to ballot. The Council may, in its discretion, by a three-fourths vote of the members present, order the name of the applicant placed on the next ballot for members.

B 9. Each person elected to membership must subscribe to the Constitution, By-Laws and Rules of the Society, and pay the initiation fee before he can receive a certificate of membership in the Society.

ELECTION OF OFFICERS.

B 10. The Secretary shall mail to each member entitled to vote, at least thirty days before the Annual Meeting, the names of the candidates for office proposed for election by the Nominating Committees.

B 11. The names of the candidates proposed by the Nominating Committee or Committees, and the respective offices for which they are candidates, shall be printed in separate lists on the same ballot sheet, each list of candidates to be printed under the names of the members of the particular committee which proposed it.

B 12. The name of any candidate on the ballot may be erased, and the name of any person qualified to hold office written in its stead. The ballot must be voted and canvassed in the same manner as for the election of members.

B 13. In case of a tie in the vote for any officer, the President, or, in his absence, the Presiding Officer, shall cast the deciding vote.

B 14. A ballot which contains more names on it than there are officers to be elected is thereby defective, and shall be rejected by the Tellers.

FEES AND DUES.

B 15. The initiation fee and annual dues of the first year shall be due and payable on notice of election to membership. Thereafter the annual dues shall be due and payable on the first day of December in each year.

B 16. A Member in arrears for one year shall not be entitled to vote until such arrears have been paid. Should the right to vote be questioned, the books of the Society shall be conclusive evidence.

B 17. The Secretary shall present to the Council the name of any Member, Associate or Junior in arrears for more than one year. A person dropped from the rolls for non-payment of dues may, at the discretion of the Council, be restored to the privileges of membership upon payment of all arrears.

FINANCIAL ADMINISTRATION.

B 18. The Council at its first meeting in each fiscal year shall consider the recommendations of the Finance Committee concerning the expenditures necessary for the work of the Society during that year. The apportioning of the work of the Society among the various standing and other Committees shall be on a basis approved by the Council and in harmony with the Constitution and By-Laws. The appropriations approved by the Council, or so much thereof as may be required for the work of the Society, shall be expended by the various Committees of the Society, and all bills against the Society for such expenditures shall be certified by the Committee making the expenditure, and shall then be sent to the Finance Committee for audit. Money shall not be paid out by any officer or employee of the Society except upon bills duly audited by the Committee, or by resolution of the Council.

FINANCE COMMITTEE.

B 19. The Finance Committee shall consist of three members of the Council appointed for a term of one year. The Committee shall, under the direction of the Council, have supervision of the financial affairs of the Society, including the books of account.

PROGRAMME COMMITTEE.

B 20. The President shall appoint a committee from the members of the Council who shall procure professional papers, to pass upon their suitability for presentation, and to suggest topical subjects for discussion at the meetings. The Committee may refer any paper presented to the Society to a person or persons, especially qualified by theoretical knowledge or practical experience, for their suggestions or opinions as to the suitability of the paper for presentation. Papers from non-members shall not be accepted except by unanimous vote of the Committee. No paper intended for publication in the Transactions of the Society shall be read at the meetings of this Society, unless a copy of it shall have been mailed to each member in printed or typewritten form at least two weeks before the date of the meeting at which it is expected to be read. It shall be the duty of the Programme Committee to cause such copies to be so mailed. This rule shall not apply to lectures or addresses offered by persons invited to deliver them by the unanimous vote of the Programme Committee. The Committee shall arrange the programme

of each meeting of the Society, and shall have general charge of the entertainments to be provided for the members and guests at each meeting. It shall prohibit the distribution or exhibition at the headquarters or at the meeting places of the Society of all advertising circulars, pamphlets or samples of commercial apparatus or machinery. At the end of each fiscal year the Committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

PUBLICATION COMMITTEE.

B 21. The Publication Committee shall consist of three members of the Council appointed for a term of one year. The Committee shall review all papers and discussions which have been presented at the meetings, and shall decide what papers or discussions, or parts of the same, shall be printed. No papers shall be published, or authorized to be published, either publicly or privately, purporting to be a part of the transaction of the Society without the authority of the Publication Committee. At the end of each fiscal year the Committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

MEMBERSHIP COMMITTEE.

B 22. The Membership Committee shall consist of three members of the Council appointed for a term of one year. It shall be the duty of this Committee:

To receive and scrutinize all applications for membership to the Society.

To seek further information as to the qualifications of any applicant whose evidence of eligibility is not clear to the Committee.

To report to each session of the Council the names of all applicants under consideration, together with the action of the Committee on each.

The Committee shall at once destroy all correspondence in relation to each applicant when his name has been placed on the ballot by order of the Council, or upon the withdrawal of the application.

NOMINATING COMMITTEES.

B 23. A Nominating Committee of five Members or Associates shall be appointed by the President within three months after he assumes office. It shall be the duty of this Committee to send to the Secretary on or before October first the names of consenting nominees for the elective offices next falling vacant under the Constitution. Upon the request of any Member or Associate, the Secretary shall furnish to the applicant the name of such nominees.

B 24. Twenty or more members entitled to vote may constitute themselves a Special Nominating Committee with the same powers as the Annual Nominating Committee. A Special Nominating Committee, if organized, shall, on or before October twentieth, present to the Secretary the names of the candidates nominated by it for the elective offices next falling vacant under the Constitution, together with the written consent of each.

TELLERS.

B 25. The Presiding Officer shall, at the first session of the Annual Meeting, appoint three Tellers of Election of Officers, whose duties shall be to canvass the votes cast, and report the result to the meeting. Their term of office shall terminate when their report of the canvass is presented to the meeting.

B 26. The President, within one month after assuming office, shall appoint three Tellers of Election of Members to serve for one year, whose duties shall be to canvass the votes cast for members during the year, and to certify the same to the President. They shall notify candidates through the Secretary of the result of such election.

B 27. The President shall appoint three Tellers to canvass any letter ballots which shall be ordered by the Council or by the Society.

SECRETARY.

B 28. The Secretary of the Society shall be the Secretary to the Council.

The Secretary shall have charge of the Books of Account of the Society, under the supervision of the Finance Committee.

He shall make and collect all bills against members or others.

All bills against the Society shall be delivered to the Secretary. He shall immediately enter them in the books of Account, and shall immediately deposit such funds as he receives to the credit of the Society in a bank to be designated by the Council.

TREASURER.

B 29. The Treasurer shall make payments only on the audit of the Finance Committee, or upon the direction of the Council, by resolution of that body. He shall furnish a bond for the faithful performance of his duties to such amount as the Council may require, such bond to be procured from an incorporated guarantee company at the expense of the Society.

TITLES, EMBLEMS, CERTIFICATES.

B 30. Each Member, Associate and Junior shall, subject to such rules as the Council may establish, be entitled on request to a certificate of membership, signed by the President and Secretary of the Society. Every such certificate shall remain the property of the Society, and shall be returned to it on demand of the Council.

B 31. Each proxy authorizing a person to vote for an absent member shall be signed by such absent member, with an attesting witness, and be submitted to the Secretary for verification of the member's right to vote at the meeting at which the right is to be exercised.

B 32. The emblem of each grade of membership approved by the Council shall be worn by those only who belong to that grade. The official stationery shall be used only by officers and committees of the Society for official business.

B 33. The abbreviations of the titles of the various grades of membership approved by the Society are as follows:

For Members—Mem. Am. Soc. R. E.
For Associates—Assoc. Am. Soc. R. E.
For Juniors—Jun. Am. Soc. R. E.

ORDER OF BUSINESS.

B 34. Roll call.
Reading of minutes of previous meeting.
Report of Tellers of Election of Membership.
Report of the Council.
Unfinished business.
New business.
Report of Tellers of Election of Officers.
Reading of papers and discussions.

PARLIAMENTARY RULES.

B 35. In all questions arising at any meeting, involving parliamentary rules not provided for in these By-Laws, "Cushing's Manual" shall be the governing authority.

AMENDMENTS.

B 36. These By-Laws may be amended in the same manner as amendments are made to the Constitution.

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PROCEEDINGS

OF THE

SECOND WESTERN MEETING

St. Louis, Mo., October 2 and 3, 1911.

The American Society of Refrigerating Engineers held a special, the second Western, meeting in the Jefferson Hotel, St. Louis, Mo., on Monday and Tuesday, October 2 and 3, 1911. Four sessions were held, Monday morning and afternoon and Tuesday morning and afternoon, all being presided over by President Edward N. Friedmann, New York, N. Y.

First Session, Monday Morning, October 2

The first session of the meeting was called to order at about 11 o'clock on the morning of October 2, and as there was more than a quorum present the calling of the roll of membership was dispensed with.

The minutes of the sixth annual meeting were read and approved. They follow:

MINUTES OF THE SIXTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.

The sixth annual meeting of The American Society of Refrigerating Engineers was held in the Engineering Societies Building, 29 West Thirty-ninth street, New York, N. Y., on Monday and Tuesday, December 5 and 6, 1910. Four sessions were held, Monday morning, afternoon and evening and Tuesday morning. The sessions were presided over by President Roderick H. Tait, St. Louis, Mo.

First Session, Monday Morning, December 5.

The first session of the meeting was called to order at about 11 o'clock A. M., and, as more than a quorum for the transaction of business were present, the calling of the roll of membership was dispensed with.

The next order of business was the reading of the minutes of the fifth annual meeting. They were accepted as read.

The report of the Tellers of Election of Membership, consisting of F. E. Matthews, Charles D. Havenstrite and E. L. Phillips, was next received. They reported that seven applicants had been elected to membership in the grade of Member, four in the grade of Associate Member and three in the

grade of Junior Member during the year. They further reported that one Junior Member had been advanced in grade of membership to Member. The President declared the successful applicants duly elected to their respective grades and entitled to the rights and privileges of membership, if they had complied with the provisions of the Constitution and By-Laws covering new members.

The report of the Council was now heard and accepted.

Under the head of unfinished business, the President called for a report of the Joint Committee on Standardization of The American Society of Mechanical Engineers and The American Society of Refrigerating Engineers. John E. Starr of this committee reported progress and stated that another meeting of the Joint Committee would be held on December 9. 1910.

The President now appointed John E. Starr, Henry Vogt and L. Howard Jenks as a Resolutions Committee, to draft resolutions on the death of members during the past year.

The next order of business was final discussion and action on the proposed amendments to the Constitution and By-Laws introduced at the fifth annual meeting. Secretary Ross moved the appointment of three tellers to canvass the votes on the proposed amendments. The motion was seconded and carried. The President appointed J. F. Nickerson, Junius H. Stone and Nelson J. Waite as the tellers.

The proposed amendment to paragraph C 26 of the Constitution, disqualifying Associate Members from holding the office of president and vice-president of the Society, was now taken up.

Paragraph C 26 of the Constitution now reads:

OFFICERS.

C 26. At each Annual Meeting there shall be elected from among the Members and Associates:

A President to hold office for one year.

Two Vice-Presidents, one to hold office for one year, and one to hold office for two years. After the first year one Vice-President to be elected annually for a term of two years.

A Treasurer to hold office for one year.

Nine Members or Associates shall be elected to the Council at the first Annual Meeting, three to hold office for one year, three to hold office for two years, and three to hold office for three years, and at each subsequent Annual Meeting three Members or Associates shall be elected, each to serve three years.

The proposer of the amendment would have it read:

OFFICERS

C 26. At each Annual Meeting there shall be elected from among the Members:

A President to hold office for one year.

Two Vice-Presidents, one to hold office for one year, and one to hold office for two years. After the first year one Vice-President to be elected annually for a term of two years.

There shall be elected from among the Members and Associates a Treasurer to hold office for one year.

Nine Members or Associates shall be elected to the Council at the first Annual Meeting, three to hold office for one year, three to hold office for two years, and three to hold office for three years, and at each sub-

sequent Annual Meeting three Members or Associates shall be elected, each to serve three years.

The proposed amendment was lost by a decisive vote.

The proposed amendment to paragraph B 20 of the By-Laws was now considered.

Paragraph B 20 of the By-Laws now reads:

PROGRAM COMMITTEE.

B 20. The President shall appoint a committee from members of the Council who shall procure professional papers, to pass upon their suitability for presentation, and to suggest topical subjects for discussion at the meetings. The Committee may refer any paper presented to the Society to a person, or persons, especially qualified by theoretical knowledge or practical experience, for their suggestions or opinions as to the suitability of the paper for presentation. Papers from non-members shall not be accepted except by unanimous vote of the Committee. The Committee shall arrange the program of each meeting of the Society, and shall have general charge of the entertainments to be provided for the members and guests at each meeting. It shall prohibit the distribution or exhibition at the headquarters or at the meeting places of the Society of all advertising circulars, pamphlets or samples of commercial apparatus or machinery. At the end of each fiscal year the Committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

The proposer of the amendment would have it read:

PROGRAM COMMITTEE.

B 20. The President shall appoint a Committee from the members of the Council who shall procure professional papers, to pass upon their suitability for presentation, and to suggest topical subjects for discussion at the meetings. The Committee may refer any paper presented to the Society to a person, or persons, especially qualified by theoretical knowledge or practical experience, for their suggestions or opinions as to the suitability of the paper for presentation. Papers from non-members shall not be accepted except by unanimous vote of the Committee. No paper intended for publication in the Transactions of the Society shall be read at the meetings of this Society unless a copy of it shall have been mailed to each member in printed or typewritten form at least two weeks before the date of the meeting at which it is expected to be read. It shall be the duty of the Program Committee to cause such copies to be so mailed. This rule shall not apply to lectures or addresses offered by persons invited to deliver them by the unanimous vote of the Program Committee. The Committee shall arrange the program of each meeting of the Society, and shall have general charge of the entertainment to be provided for the members and guests at each meeting. It shall prohibit the distribution or exhibition at the headquarters or at the meeting places of the Society of all advertising circulars, pamphlets or samples of commercial apparatus or machinery. At the end of each fiscal year the Committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

The proposed amendment was adopted.

The amendment to paragraph B 21 of the By-Laws was next taken up.

Paragraph B 21 of the By-Laws now reads:

PUBLICATION COMMITTEE.

B 21. The Publication Committee shall consist of three members of the Council appointed for a term of one year. The Committee shall review

all papers and discussions which have been presented at the meetings, and shall decide what papers and discussion, or parts of the same, shall be printed. At the end of each fiscal year the Committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

The proposer of the amendment would have it read:

PUBLICATION COMMITTEE

B 21. The Publication Committee shall consist of three members of the Council appointed for a term of one year. The Committee shall review all papers and discussions which have been presented at the meetings, and shall decide what papers or discussions, or parts of the same, shall be printed. No papers shall be published or authorized to be published, either publicly or privately, purporting to be a part of the Transactions of the Society, without the authority of the Publication Committee. At the end of each fiscal year the Committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

The amendment was adopted.

A discussion was now had as to increasing the membership of the Society and resulted in the understanding that each member was to make special efforts to secure new members for the Society, particularly in the grade of Junior Member.

The report of the Tellers of Election of Officers, consisting of Nelson J. Waite, J. J. Wuertenbaecher and J. F. Nickerson, was now received. They reported that the following members had been elected to the offices indicated:

President—Edward N. Friedmann, New York, N. Y.
Vice-President—Albert Ruemmeli, St. Louis, Mo.
Treasurer—Walter C. Reid, New York, N. Y.
Directors—Louis Block, New York, N. Y; Louis Doelling, New York, N. Y.; Thomas Shipley, York, Pa.

President Tait declared the new officers duly elected and appointed Ex-Presidents John E. Starr and W. Everett Parsons as a committee to escort President-elect Friedmann to the platform.

In accepting the presidency, President-elect Friedmann stated:

"I, of course, wish to thank you most heartily for the honor conferred upon me, and, particularly so, when I consider that there are so many members of far greater ability in the Society from which to choose. However, you have elected me and so you will have to take the consequences.

"The field of refrigerating engineering is widening from day to day, and new problems are coming up more frequently than ever; and it is not only desirable but absolutely necessary that all members of the engineering fraternity work in hearty co-operation. The refrigerating science, as I look at it to-day, is still in its infancy; and it is only in the last few years that it has been put on a more scientific basis and that its problems have been treated more scientifically. It is not so very far back—and many of our members will remember it—for instance, when I was told by an operating engineer that the proper way to run a refrigerating machine was to have the condenser pressure exactly ten times the suction pressure, and that an essential part of a plant was a hot-water connection for the condenser, so that in the winter time, when the pressure would get too low, it could be raised to the proper height. Such things, of course, are really out of the question to-day; and particularly due to the fact that we have to-day, through the benefits of this Society, a good many reliable data. I think we owe a debt of gratitude to the men who

have furnished these data, whether they are independent engineers or manufacturers or teachers, considering particularly that to obtain such data usually involves a great deal of time and expense. I think they show the utmost unselfishness in presenting them to us, as they have done.

"A good deal has been done and a good deal more remains to be done. It is natural that engineers look to this Society for information, and it is lucky for us that we have a great number of members who are eminently qualified to speak with authority on questions pertaining to our branch of engineering. In fact, some of them, I believe, can speak with equal authority from both the practical and scientific sides of the question, if they try.

"In conclusion, I wish to say, considering the ability and sterling qualities of my predecessors, it seems a rather hard task to equal or even approach their record, but with the help of the members, the Council and our worthy Secretary, I shall try to do my best; and, if I fail, I wish you would attribute it more to lack of knowledge or ability than to lack of goodwill or honest endeavor. I thank you once more for the honor."

The session now adjourned for luncheon in the Engineering Societies Building, arranged for by the Program Committee.

Second Session, Monday Afternoon, December 5.

The second session was called to order at about 1.30 o'clock P. M.

The following papers were presented at this session: "Corrosive Effect of Calcium Chloride Brine on Metals," by Dr. Allerton L. Cushman, Washington, D. C.; "A Gas Producer Operated Refrigerating Plant," by R. H. Tait, St. Louis, Mo., and "The Economic Value of Insulation," by Julius H. Stone, New York, N. Y.

A vote of thanks was extended Dr. Cushman for his valuable paper.

The session then adjourned.

Third Session, Monday Evening, December 5.

The third session of the meeting was called to order at 8.30 o'clock P. M., and the reading and discussion of papers was immediately taken up.

The papers read at this session were: "Practical Constants in the Theory of Refrigeration," by Charles Jonsson, New York, N. Y., and "Precooling of Fruit," by Arthur Faget, San Francisco, Cal.

The session then adjourned.

Fourth Session, Tuesday Morning, December 6.

The fourth and final session of the meeting was called to order about 11 o'clock A. M.

The papers read at this session were: "Clearance and Its Effects on the Volumetric Efficiency of Ammonia Compressors," by Van Rensselaer H. Greene, New York, N. Y., and "Clearance in Single-Acting and Double-Acting Compressors," by Thomas Shipley, York, Pa.

Votes of thanks were extended to both Mr. Greene and Mr. Shipley for their valuable contributions to the data of the Society.

The report of the Resolutions Committee was now received. Its resolution on the death of James Wills was as follows:

JAMES WILLS

The American Society of Refrigerating Engineers, at their annual meeting held December 5 and 6, 1910, record with deep regret the death

of their Past Vice-President, Mr. James Wills of New York, N. Y., which occurred in that city on March 29, 1910.

Mr. Wills was one of the prominent pioneers in the art of the cold storage of perishable goods and in the application of refrigerating machinery, insulation and appliances having a bearing on this important branch of refrigerating work.

The last twenty-five years of his life were practically devoted to this division of the subject and his experiments, both on a laboratory and a practical scale, have constituted an important contribution to the knowledge which this Society is seeking.

During the years 1907 and 1908 he was a valuable member of our Council and Vice-President of this Society.

Notwithstanding his daily work, Mr. Wills found time to gratify his tastes for art and literature, rounding out his life not only as a useful man from a technical and business standpoint, but in those other accomplishments that are quite as important in the life of man.

Those who knew him best will appreciate most his kindly and genial personality and this Society, as a body, feels that they have lost a valuable and most companionable member.

Resolved, That this resolution be spread on the records of the Society and that the Secretary be instructed to send a copy to the family of our late associate.

Members of the Society, who attended the Second International Congress of Refrigeration in Vienna, were now called on to give some of their experiences abroad and describe some of the refrigerating installations that they had visited. Remarks were heard from Theodore O. Vilter, Theodore Kolischer and J. F. Nickerson.

After some discussion as to the manner of the Society co-operating with the American Association of Refrigeration relative to the Third International Congress of Refrigeration, the following resolution was passed:

"The American Society of Refrigerating Engineers in convention assembled extends its moral support to the American Association of Refrigeration in holding the Third International Congress of Refrigeration in the United States."

The financial co-operation of the Society with the American Association of Refrigeration in holding the Third International Congress of Refrigeration was referred to the Council with power to act.

The following telegram from J. B. Embrey, Secretary and Treasurer of the Practical Refrigerating Engineers Association, was now read:

"The first annual convention of the Practical Refrigerating Engineers Association sends greetings to The American Society of Refrigerating Engineers in convention at New York and invites co-operation and recognition in the interest of the practical refrigerating engineers of the country."

The Secretary was instructed to send a letter to the Secretary of the Practical Refrigerating Engineers Association, reciprocating their greetings and assuring them of the Society's co-operation.

Discussion on the co-operation of the Society with other organizations to defeat proposed inimical State and Federal cold storage legislation resulted in a motion by Henry Torrance, Jr., which was seconded and carried, authorizing the President to appoint a committee of three for the purpose stated. President Tait appointed Henry Torrance, Jr., Homer McDaniel and Frank A. Horne on this committee.

On motion of Thomas Shipley, a unanimous vote of thanks was extended President Tait for the splendid manner in which he has represented the Society and the honor he has conferred upon the Society by acting as its President.

In accepting the vote of thanks, President Tait said:

"It is I who have to express thanks for the honor you have done me in making me your President for the past year and for the large attendance at our meetings. We have had a good meeting, full of interest, that is what brings members together. I wish to express my deepest gratitude for your solicitous kindness and consideration of me during the meeting."

The meeting then adjourned.

(Signed) W. H. Ross, *Secretary.*

Two reports of the Tellers of Election of Membership were now received. They were as follows:

REPORTS OF THE TELLERS OF ELECTION OF MEMBERSHIP.

NEW YORK, N. Y., August 11, 1911.

MR. EDWARD N. FRIEDMANN, President,
The American Society of Refrigerating Engineers,
154 Nassau Street, New York, N. Y.

DEAR SIR:—Your Tellers of Election of Membership met this afternoon and canvassed the ballots for new members closing July 30, 1911, and beg to report the election to membership in the grade indicated of the following gentlemen:

MEMBERS.

F. M. Aday, New York, N. Y.
C. E. Allison, New York, N. Y.
Norman H. Armour, Chicago, Ill.
Charles G. Armstrong, New York, N. Y.
John Hague, St. Louis, Mo.
F. W. Langley, Los Angeles, Cal.
Frederick L. Pryor, Hoboken, N. J.
E. T. Williams, New York, N. Y.

ASSOCIATE MEMBERS

Ellsworth L. Long, New York, N. Y.
L. A. Roy, Chicago, Ill.

Respectfully submitted,

(Signed) L. HOWARD JENKS, Chairman, } *Tellers of*
ROBERT N. BAVIER, } *Election of*
FRANK A. HORNE. } *Membership.*

NEW YORK, N. Y., September 26, 1911.

MR. EDWARD N. FRIEDMANN, President,
The American Society of Refrigerating Engineers,
154 Nassau Street, New York, N. Y.

DEAR SIR:—Your Tellers of Election of Membership met this afternoon and canvassed the ballots for new members closing September 25, 1911, and beg to report the election to membership in the grade indicated of the following gentlemen:

MEMBERS.

E. W. Gallenkamp, Jr., St. Louis, Mo.
J. Laichinger, St. Louis, Mo.
Louis B. Von Weise, St. Louis, Mo.
George E. Wells, St. Louis, Mo.

ASSOCIATE MEMBERS.

William H. Bower, Philadelphia, Pa.
R. E. Bridgette, Brooklyn, N. Y.
William Meeske, New York, N. Y.
H. Richmond, New York, N. Y.
Charles W. Rodgers, New York, N. Y.
C. E. Rose, Little Rock, Ark.
C. L. Whittemore, St. Louis, Mo.

JUNIOR MEMBERS.

Charles F. Schulte, St. Louis, Mo.

Ninety-three ballots were cast, three of which were void for want of signature on the outer envelope, and another contained a notation on the ballot.

Respectfully submitted,

(Signed) L. HOWARD JENKS, Chairman, FRANK A. HORNE, } *Tellers of Election of Membership.*

President Friedmann declared the successful applicants duly elected in their respective grades. He also urged the members to work to still further increase the membership.

Under the heading of new business, invitations to co-operate with the Eighth International Congress of Applied Chemistry and the Sixth Congress of the International Association for Testing Materials were read and referred to the President with power to act.

The next order of business was a paper by President Friedmann on "Advantages of Operating Ammonia Compressors by Aid of Thermometers," which was generously received, with Vice-President Albert Ruemmeli, St. Louis, Mo., in the chair.

At this point Vice-President Ruemmeli introduced Robert Burkham, as representing Mayor Frederick Kriesman, who delivered an address of welcome to St. Louis, which was very cordially received. A suitable response was made by President Friedmann.

The session now adjourned for luncheon as guests of the St. Louis members of the Society and their friends.

Second Session, Monday Afternoon, October 2

The second session of the meeting was called to order about 1.30 o'clock P. M.

Henry Torrance, Jr., chairman of the Cold Storage Legislation Committee, made the following report by telegraph:

NEW YORK, N. Y., October 2, 1911.

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS,
Jefferson Hotel, St. Louis, Mo.

The Committee on Legislation reports as follows: This committee attended a hearing in Albany and subsequently a New York bill was passed which was not objectionable. It also worked in conjunction with the committee of the American Warehousemens Association on New Jersey legislation, sending out many letters, and also at Washington. It recommends that all engineers read the report of United States Senate Manufacturers Committee entitled "Foods Held in Storage." Further work may be required, and it is suggested that this committee be continued or a new one appointed to continue the work.

HENRY TORRANCE, JR.

The report was accepted and the committee continued.

The following invitation was extended by the Merchants' Exchange of St. Louis:

ST. LOUIS, October 2, 1911.

TO THE OFFICERS AND MEMBERS OF THE AMERICAN
SOCIETY OF REFRIGERATING ENGINEERS:

GENTLEMEN:—I take great pleasure in extending a cordial invitation to the members of your association to visit the Merchants Exchange, either in person or in a body, as may best suit your convenience, during your sessions in this city. Your badge will admit you.

If there are ladies in your party, would be glad to have them call and view the Exchange from the ladies' gallery.

Yours very truly,
JAMES W. GARNEAU, *President.*

The Secretary was instructed to write President Garneau, thanking both him and the Merchants' Exchange of St. Louis for their kindness.

An invitation to visit the power plant of the Union Electric Light and Power Company was extended through Roderick H. Tait and he was requested to thank them for it.

The papers presented at this session were "Problems Encountered in the Design and Construction of an Ammonia Compression Test Plant," by Van Rensselaer H. Greene, New York, N. Y., and "Steel Pipe versus Wrought Iron Pipe in Refrigerating Work," by P. De C. Ball, St. Louis, Mo.

The topic "What Is the Meaning of the Term 'Usual Wear and Tear' in Contracts for Refrigerating Machinery?" was also discussed at this session.

The session then adjourned for a delightful automobile ride about the parkways of St. Louis and a splendid dinner at Sunset Inn, the old U. S. Grant farm, as guests of the St. Louis members.

Theodore O. Vilter, Milwaukee, Wis., acted as toastmaster and addresses were made by President Friedmann, Vice-President Ruemmeli, John Laird, St. Louis, Mo.; George T. Tansey, St. Louis, Mo.; William Reedy, St. Louis, Mo.; Louis Block, New York, N. Y.; Victor H. Becker, Chicago, Ill.; Albert Widmann, St. Louis, Mo.; Thomas Shipley, York, Pa.; Henry Vogt, Louisville, Ky.; J. J. Wuertenbaecher, St. Louis, Mo.; Peter Neff, Canton, Ohio; J. F. Nickerson, Chicago, Ill., and W. S. Ashton, St. Louis, Mo.

Third Session, Tuesday Morning, October 3

The third session of the meeting was called to order about 10 o'clock A. M., and the first order of business was the presentation of a letter from W. L. Holzbaur, Kansas City, Mo., on the committee appointed to represent the Society at the Third National Conservation Congress. Mr. Holzbaur stated that the Society was properly represented at the congress and briefly stated the work of the congress.

A telegram of greeting and regret was read from Dr. J. E. Siebel, Chicago, Ill.

The papers read at this session were "Cold Storage Legislation —State and Federal," by R. H. Switzler, St. Louis, Mo., and "The High Speed Ammonia Compressor," by Theodore O. Vilter, Milwaukee, Wis., and a lecture on "Cooling Towers," by Albert Ruemmeli, St. Louis, Mo.

A vote of thanks was extended Mr. Switzler for his very interesting paper.

The session then adjourned for luncheon as guests of the St. Louis members.

Fourth Session, Tuesday Afternoon, October 3

The fourth and final session of the meeting was called to order at about 1.30 o'clock P. M., and a paper on "The Protection of Refrigerating Apparatus Against Corrosion," by Morgan B. Smith, Syracuse, N. Y., was presented at this session. A vote of thanks was extended Mr. Smith for his very valuable contribution to the data of the Society.

Jacob T. Wainwright, Chicago, Ill., also made a few remarks on "A Thermodynamic Phenomenon," which were generously received.

A hearty vote of thanks was extended the St. Louis members of the Society and their friends for the splendid entertainment they had given the members and guests during the meeting.

The meeting then adjourned, followed by an automobile trip and inspection of the brewery and ice manufacturing plant of the Anheuser-Busch Brewing Association.

W. H. Ross, *Secretary.*

MEMBERS AND GUESTS ATTENDING ST. LOUIS MEETING.

Anderson, G. W., St. Louis, Mo.
Armour, Norman H., Chicago, Ill.
Atwood, J. C., St. Louis, Mo.
Ashton, Walter S., St. Louis, Mo.
Ball, P. DeC., St. Louis, Mo.
Bannon, Walter W., Oklahoma City, Okla.
Becker, V. H., Chicago, Ill.
Becker, V. H., Jr., St. Louis, Mo.
Berna, G., St. Louis, Mo.
Block, Louis, New York, N. Y.
Borchers, H. L., St. Louis, Mo.
Bower, W. H., Philadelphia, Pa.
Chamberlin, George E., St. Louis, Mo.
Delle, Frank A., St. Louis, Mo.
Fisher, G. H., Leavenworth, Kan.
Fitzgerald, John J., St. Louis, Mo.
Frazer, C. A., St. Louis, Mo.
Frerichs, F. W., St. Louis, Mo.
Friedmann, E. N., New York, N. Y.
Fuller, Roy E., Chicago, Ill.
Gallenkamp, E. W., Jr., St. Louis, Mo.
Girtunner, Fred, St. Louis, Mo.
Greene, Van R. H., New York, N. Y.
Hague, John, St. Louis, Mo.
Hamilton, J. R., St. Louis, Mo.
Havenstrite, Charles D., Chicago, Ill.
Hawkins, J. Arthur, New York, N. Y.
Heinrich, Edward E., St. Louis, Mo.
Hymers, Ewing, St. Louis, Mo.
Johnson, Albert, St. Louis, Mo.
Jorgensen, H., E. St. Louis, Ill.
Karl, Robert H., St. Louis, Mo.
Keally, J. M., St. Louis, Mo.
Kerbel, C. Joseph, Louisville, Ky.
Kleucker, George M., St. Louis, Mo.
Klock, John J., St. Louis, Mo.
Klunk, J. H., Philadelphia, Pa.
Koedding, William, St. Louis, Mo.
Laichinger, John, St. Louis, Mo.
Louis, J. S., Cincinnati, Ohio.
McCandlish, R. M., Kansas City, Mo.
McGinnis, W. R., Chicago, Ill.
McPartlin, S. E., Chicago, Ill.
Mason, Dale R., Pittsburg, Pa.
Moore, Herbert, Memphis, Tenn.
Moore, H. W., Springfield, Mo.
Neff, Peter, Canton, Ohio.
Nelson, H. P., St. Louis, Mo.
Nickerson, J. F., Chicago, Ill.
Nordmeyer L. C., St. Louis, Mo.
Ormsby, Erle, St. Louis, Mo.
Robbins, H. S., St. Louis, Mo.
Robertson, G. A., Louisville, Ky.
Ross, W. H., New York, N. Y.
Ruemmeli, A., St. Louis, Mo.
Schadek, Edward W., St. Louis, Mo.
Schulte, Charles F., St. Louis, Mo.
Schraulstadt, George, St. Louis, Mo.
Shipley, Thomas, York, Pa.
Sickmeyer, Ben. W., St. Louis, Mo.
Smith, Morgan B., Syracuse, N. Y.
Stjemstedt, J. W., St. Louis, Mo.
Stephens, L. H., Jr., St. Louis, Mo.
Stockman, O. S., Pittsburg, Pa.
Switzler, R. H., St. Louis, Mo.
Tait, R. H., St. Louis, Mo.
Tolkalz, Emil W., St. Louis, Mo.
Urbauer, H. F., St. Louis, Mo.
Vilter, Theodore O., Milwaukee, Wis.
Vogt, Henry, Louisville, Ky.
Von Weise, L. B., St. Louis, Mo.
Wainwright, Jacob T., Chicago, Ill.
Westerfield, William, Atlanta, Ga.
Whittemore, C. L., St. Louis, Mo.
Widmann, F., St. Louis, Mo.
Wills, W. H., New York, N. Y.
Wuertenbaecher, J. J., St. Louis, Mo.
Zilker, Charles A., San Antonio, Tex.

PAPERS OF THE

SECOND WESTERN MEETING

ST. LOUIS, MO., October 2 and 3, 1911

No. 87

PRESIDENTIAL ADDRESS—ADVANTAGES OF OPERATING AMMONIA COMPRESSORS BY AID OF THERMOMETERS.

By Edward N. Friedmann, New York, N. Y.

The few remarks I wish to make may call attention to points which, if properly observed, may be the means of avoiding trouble in some cases; at all events, they can be only beneficial. I refer to the question of the competent handling or manipulating of a refrigerating plant. The owner may use the best care in placing his order; the manufacturer may, and usually will, use every means to produce a first-class outfit, suitable for a particular purpose; the owner may be willing to buy the best of material, such as packing, oil, etc.; and still, after all has been done in accordance with good business methods, the plant may not show the capacity or economy which may be reasonably expected, simply because the man who is handling it has never been properly instructed, and, accordingly, is not able to benefit by the numerous tests made by manufacturers and independent engineers.

In other words, the plant, no matter how well constructed, is at the mercy of the operating engineer, and may be a success or a failure, according to his knowledge. No one knows this better than the manufacturer. He naturally tries to protect his interests by inserting a clause in his contract to the effect that certain guarantees as to capacity, temperature, and economy are based on the condition that the plant is to be properly handled, according to his instructions, by a competent engineer; and he reserves the privilege of putting his own man in charge, if necessary, to prove that the plant, if properly handled, will produce the results guaranteed.

Now, for illustration, let us assume that the performance of the plant is not satisfactory to the owner, who, in most cases, will have to rely on the statement of his operating engineer, and he demands that a test be made as to capacity, etc. What is the first thing that the manufacturer does? I am speaking here of manufacturers of reputation and standing; not of some little pipe fitter who calls himself a manufacturer, after having helped erect machines for some-

one else for a few months, or even years. He sends his men and inserts thermometer wells in suction and discharge pipes near the compressor, and at other places in the outfit where the reading of temperatures is of any importance. In some cases these wells, as well as instruments, are already provided, but in most cases, as you know, they are not. This refers particularly to the ammonia compressor connections. Preliminary to test, and during the test, the temperatures of suction and discharge gas are carefully taken at very frequent intervals, proving thereby that he regards it of great importance for his purpose of getting the best results. He also takes indicator cards, but does not seem to attach much importance to them, except to find out whether the valves are working properly and the pistons are tight. He regulates the back pressure to that most suitable for the particular plant, and under prevailing local conditions.

Is it not natural to conclude, therefore, that if this temperature reading is so important to the manufacturer to produce the best results, it is just as important to the owner, since, naturally, the closer he can run his plant to test conditions the better? Of course, other readings are made also during the test, such as temperature of water on and off ammonia condensers, on and off steam condensers, etc., and these readings are made frequently, at regular intervals, and are taken into consideration. While in the regular manipulation of plants this cannot well be done as frequently as during a test, still in too many cases it is almost entirely neglected.

The manufacturer is usually entitled under his contract to a certain amount of cooling water of a certain temperature, or its equivalent. Whether this "equivalent" is really proper is another question. At any rate, local conditions sometimes make it necessary in order to have something to go by. If, for instance, well water at 56 to 60 degrees Fahr. is available, and the well pump gives out, or if for any other reason the supply should fail, city water or river water of a much higher temperature may have to be used, with a consequent increase in condenser pressure, or temperature of distilled water, if it is an ice-making plant.

Leaving aside this consideration at present, how many operating men regard these temperature readings of sufficient importance to enter them into their daily logs, where such are kept, more frequently than possibly twice a day? And how often do they discuss these figures with their men, in order to improve the operation of the plant?

Those who attended our last meeting in New York will remember the discussion in regard to superheat outside of the compressor, and in what way this superheat quite seriously affects the capacity of a compressor. Yet how often is the temperature of the suction gas taken by the operating man? and if taken, how often is he in a position to draw the proper conclusions and provide remedies, if such are needed?

I can state from my own experience that in a fairly large-sized plant, where the operating engineer is as good a man as you can expect to find in such a position, and where the owners are highly pleased with his efficiency, I found the ammonia suction gas superheated 31 degrees. The suction pipe was not covered, and the engineers were very careful not to let any frost get to the compressors, knowing that it might cause leakage around the stuffing boxes. In fact, they proposed to take the return first through a water-cooling tank, in order to prevent frost. In the early days of ice-machine building, you will remember that one of the foremost builders ran the return over the condensers for a similar purpose. This practice, however, was very quickly discontinued after its effect on the capacity of compressors was found.

A NUMERICAL EXAMPLE.

In the instance above mentioned, there is no question that if the thermometers had been used earlier, the constant losses in capacity could have been avoided, or at least minimized. Let us assume, for illustration, that the compressor was a 16 x 24-inch single-acting, running at 78 revolutions, with a back pressure of 15.67 pounds:

T_2 = temperature corresponding to back pressure = 0 degree Fahr.
V_2 = specific volume or volume of one pound = 9 cubic feet.
Displacement of compressor in cubic feet per minute = 435.

Displacement, 435 cubic feet ÷ 9 (the specific volume corresponding to back pressure of 15.67 pounds) = 48.33 pounds, on the basis of 100 per cent. volumetric efficiency; that is, the pounds of ammonia the compressor would deliver if there were no losses of any kind. Now, assuming a superheat of 31 degrees Fahr., or the ammonia entering the compressor at 31 degrees Fahr. instead of 0 degree Fahr., corresponding to 15.67 pounds back pressure, the question is, how much less is the volumetric efficiency?

A table published at our last meeting in New York, and also in the January number of *Cold Storage and Ice Trade Journal,*

shows that for each degree Fahr. increase of temperature, with a back pressure of 15.67 pounds, the volume increases 0.022 cubic foot per pound. Consequently, for 31 degrees Fahr. the increase in volume is $0.022 \times 31 = 0.682$. Therefore the volume occupied per pound of ammonia will be 9.682, instead of 9 cubic feet, and compressor will deliver $435 \div 9.682 = 44.9$ pounds, the loss being $48.33 - 44.9 = 3.43$ pounds, or, figuring 0.4 pounds per ton, 8.575 tons.

By having the suction pipe properly insulated, and better regulating the flow of ammonia to compressor, a good deal of this loss could have been avoided. The operating engineer in question is a man perfectly willing to be shown, and on being shown, immediately gave proper instructions to his men. Unquestionably there are many such cases, and the sooner the operating man learns to use the thermometer, the better for his employer, as well as the manufacturer.

I can also mention a case of the other extreme. There were two machines with two compressors, each manipulated in such a manner that a great amount of liquid was allowed to enter the compressors. The compressor cylinders were frosted all over, and the discharge pipe was barely hand-warm. The worst of it, however, was the fact that this liquid was taken direct from the ammonia receiver in engine room, forming, you may say, a short circuit and interfering very seriously with results in the cellars and beer coolers, on account of raising the back pressure to about 45 pounds, even when the machines were running at full speed. In this case the operating man claimed he was so instructed by the manufacturer's erecting engineer. This, however, I doubt. He simply got things mixed up, and what the erecting engineer told him, most likely, was to allow a little ammonia to enter compressor if it got too hot, not having any water jacket.

IMPORTANCE OF CORRECT DISCHARGE TEMPERATURES.

Let us see whether we can ascertain the loss of capacity by using the discharge temperature. Assuming a condenser pressure of 185 pounds, which is usual under summer conditions, the discharge temperature of the gas taken from test records is about 240 degrees Fahr. for 15 pounds back pressure. This temperature was lowered to 100 degrees Fahr. by the injection of liquid ammonia, which, however, was a loss to the refrigerating outfit. Taking the same compressors as above with a capacity of handling about 40 pounds of ammonia per minute, under 15 pounds back pressure, cor-

responding to an 82 per cent. efficiency, the loss would be sp. ht. x lbs. x $(T - T_2) = \frac{40}{2}(240 - 100) = 2{,}800$ B. t. u. per minute. If the average latent heat is 500 B. t. u., the loss would be $\frac{2800}{500} = 5.6$ pounds; and assuming 0.4 pound per minute per ton, this loss amounts to $\frac{5.6}{0.4} = 14$ tons of refrigeration.

This latter case is rather exceptional. Still, I have found several similar ones, in vertical. as well as horizontal machines. In the case just mentioned, it was a rather hard job to get the engineers to run with what they thought excessive discharge temperatures. In fact, when some oil on the outside of the pipes began to smoke, they retired to an adjoining yard, leaving me in sole possession of the engine room, and watched me through a window at what they thought was a safe distance. They finally got used to it, however, and are now using thermometers with very good results.

I do not mean to say that an operating man who does not use thermometers is on that account alone incompetent, but I do say that he would be more competent if he did use thermometers, since it teaches him the relations existing between volumes and temperatures. I have also found that, after getting used to this method, the engineer is usually very fond of it, and educates himself still further, so that in many cases he is enabled to run the machine slower.

It is not easy to introduce the method of operating compressors by the aid of thermometers; it requires patience and work. But it will undoubtedly come, and the sooner the better. You will agree with me that it is easy enough to detect radical defects, such as broken valves, leaky pistons on account of broken packing rings or the cutting of cylinder walls, sometimes with the aid of an indicator, sometimes without; but, at best, the indicator only shows whether any of the above defects exist, and whether there is any excessive clearance, and, consequently, re-expansion. It, of course, gives a chance to remedy these defects, unless the general construction of the compressor prohibits it; but even if the indicator diagram does not show any plain defects, and even if the compressor is in fairly good working condition, still its capacity may vary considerably according to how it is handled. It is in preventing the small continu-

ous losses that the competent operating engineer can prove his value. Naturally, it will not do to simply tell him that he must run the compressors as close as possible to test conditions, which means in a manner to get the greatest capacity, and also the greatest economy, it is necessary to show him how to do it.

In cases where tests have been made, the engineer naturally will learn a whole lot if he keeps his eyes open and is willing to learn; but in the majority of cases no test is ever made, and the compressors may be run for years under faulty conditions of operation; and unless proper instructions are made part of the engineer's daily routine, will continue to be so run. An operating man cannot be expected to show the same results continuously as are shown in a test, where the manufacturer sends his test men, experts in their business; and as a matter of fact, making tests in the right way to protect the interests involved is quite an art in itself, as we all very well realize from a lot of former discussions on this particular subject.

Generally speaking, I believe there are more mistakes made in allowing too much liquid to enter the compressor than the opposite; it is important, therefore, to give the engineer some kind of a guide to prevent this, since, in my opinion, it is less detrimental to allow a very slight superheat than to flood the compressor. I therefore suggest giving the instructions in the form of the following short table:

TABLE I.

SUCTION PRESSURES AND TEMPERATURES.

Gauge Pressure.	Boiling Point.	Temperature at which Suction Gas shall enter Compressor.
12¼	—5 degrees Fahr.	+3 degrees Fahr.
15.67	0 degrees Fahr.	+7 degrees Fahr.
19.46	+5 degrees Fahr.	+11 degrees Fahr.
23.64	10 degrees Fahr.	+16 degrees Fahr.
28.24	15 degrees Fahr.	+20 degrees Fahr.
33.25	20 degrees Fahr.	+25 degrees Fahr.
38.73	25 degrees Fahr.	+28 degrees Fahr.
44.72	30 degrees Fahr.	+33 degrees Fahr.

The idea is plain. If his gauge shows about 20 pounds back pressure his thermometer on suction should show about 11 degrees Fahr. This table, of course, is not perfect, but if we all get together and compare notes it should be possible to make up a table which is nearly correct, and which will at least give a man an idea how to

handle his expansion to get best results. If the suction gas is handled right the discharge will take care of itself. Since, however, I have found that the idea as to what a reasonable discharge temperature is, is very hazy in the minds of operating men, who are not in the habit of making tests, I think it is necessary to give them also an idea of how these temperatures usually run. From various tests the following figures suggest themselves:

TABLE II.

DISCHARGE TEMPERATURES.

Back Pressure.	Single Acting Compressor.	Double Acting Compressor.
5	260 degrees Fahr.	300 degrees Fahr.
15	240 degrees Fahr.	287 degrees Fahr.
25	213 degrees Fahr.	253 degrees Fahr.

This table assumes cooling water to be of an initial temperature of 60 degrees Fahr. For higher temperatures add the difference in temperature of the water to the above figures, and for lower temperatures deduct the difference. This table, also, is only to indicate averages, but is sufficiently correct to give the operating man a clue as to what temperatures he may expect.

As a matter of fact, the engineers of the manufacturers, especially of those having a test plant, are undoubtedly much more familiar with these figures than anybody else, and the object of these remarks is to put it before the manufacturers to give the operating man the benefit of their findings and enable him, thereby, to run his plant more scientifically and more economically. They have already done a great deal, in giving us the data obtained by them at an enormous expense, and deserve our lasting gratitude. I feel sure they will also do all in their power to help the operating man, who very seldom has access to their data, or, if he has, only looks upon them as a conglomeration of figures very nice, and possibly of some interest to college professors, but having no direct bearing whatever on his particular case. Of course, they have a very direct bearing on his case, but he does not realize it, probably because it has not been put to him in the proper light. Therefore, it is necessary to establish tables with data easily understood, so that the operating engineer, whether he understands the principles involved or not, will be able to run his compressor in a more rational way than is often

the case now, and make himself thereby not only more valuable to his employer, but also of help to the manufacturer, in that, in many cases, the expenses and time for tests may be saved.

DISCUSSION.

V. R. H. Greene.—I think our President deserves a great deal of credit for introducing a new idea in the operation of ammonia compressors. It seems to me that since the testing plant has become such a popular thing in the hands of the manufacturer, we have started on a new era. This is particularly noticeable in the use of thermometers in place of pressure gauges, because the whole science of refrigeration is now basing itself on temperatures rather than pressures. For example, in the old-style plants we always supplied pressure gauges for the suction and the discharge pressures. Now, it is not an unusual thing to go into those old-style plants and find a very peculiar condition existing. Many of you probably have been in a plant where you were told that the refrigerating machine was not doing good work now; that it was not able to cool the brine as it did in the past. You will find the machine probably running about as low as 30 revolutions a minute, the back pressure down to about ten pounds, and the cooling medium—water or brine, whatever it is—away up, much higher than it ever was intended to be, and yet the engineer cannot understand what causes all this trouble. The suction lines are always black and the discharge lines very hot, and you will probably discover that the pressure, instead of being ten pounds, is fifty, though the engineer does not know it. Now, he would forget all about these pressure gauges and just use them as a means of controlling the water supply when making repairs, and simply govern his operations by the frosting back, allowing it to just reach the compressor. Then, irrespective of what may be the back pressure, he must have obtained ideal conditions. If, under such conditions, he cannot get the brine down to the temperature that is required, then he must run the machine faster until he reaches the limit, and there is no possible chance of trouble, and it makes the thing a particularly easy proposition.

There is only one point on which I cannot agree with our President; and that is the subject of discharge temperatures. In this particular test, you will notice he says that the discharge temperature under a 15-pound back pressure, or 185-pound condenser pressure, in one case is 240 degrees Fahr., and in the other 267 degrees Fahr. Now, that discharge temperature is made up of three im-

portant items—internal superheat, external superheat and the heat of the brine. Of those three items, there is one that is absolutely controlled—that is the external superheat. The internal superheat may be controlled to a certain extent by the temperature and quantity of the water that goes through the jackets. To what extent it is controllable we do not know.

The difficulty of making tests in the average plant is due to the fact that we have to deal with a whole lot of variables, and we cannot make our figures check unless we have some method of keeping the variables constant. That necessitates having an observer watching all of them closely and keeping record, without which we cannot make much progress. You will find in the average plants, on reading the thermometers, that the suction temperatures vary considerably, even though the suction lines have frost on them, because the frost only indicates a temperature below the freezing point.

Take the President's figures of 287 degrees and 240 degrees; it shows directly that there is 47 degrees difference. That 47 degrees shows at once that the volumetric efficiency is down 12 per cent., and that, of course, correspondingly affects the horsepower per ton. Now, I do not believe that there are to be found such variations in double-acting compressors run under the same conditions, if they are operated exactly the same.

On taking average tests of single-acting and double-acting machines, making a note of the discharge temperatures, and bringing them both to the same temperature, you will find that the compressor capacities will be practically equal. That stands to reason, because you can control the external superheat. The internal superheat is based to a certain extent upon the diameter, increasing inversely as the diameter. Those two temperatures should be equal. I do not think there are very many double-acting compressors on the market that will show such results under similar conditions.

President Friedmann.—I am glad to learn that Mr. Greene agrees in a general way with the idea that the making of this subject intelligible to the operating man is correct. Whether or not the figures given here just fit his particular case, or his particular compressor, has nothing to do with the main question at issue. I am only putting before you the question, whether it is not proper, instead of upbraiding the operator, to give him something tangible that will show him how to run his compressors.

Now, if the compressor which Mr. Greene has in mind shows a different discharge temperature from this test, it is perfectly proper

for him to establish his own tables in his test plant, and to furnish with each plant, where this particular kind of compressor goes, his own figures for the guidance of the engineer. I am glad he said what he did.

It would be of great interest to us if everybody having test plants, particularly Mr. Greene, would establish additional data for discharge temperatures of single-acting and double-acting compressors, run under the same conditions, if possible. From the data at my disposal, these figures are justified. If somebody in our Society, at a later meeting, wants to improve on these tables, it will be interesting.

P. De C. Ball.—I understand the table is for the practical operating engineer?

President Friedmann.—Yes.

P. De C. Ball.—And for the technical man?

President Friedmann.—Exactly.

P. De C. Ball.—Having used the thermometers on suction and discharge lines of large compressors since 1897, I find that your data there of fifteen pounds back pressure corresponds with the discharge temperature of about 287 degrees, with jacket water of 80 degrees, on our double-acting compressor. I think that in operating the compressor, especially in large plants, the thermometer, with the indicator, will show any practical operating man how to run the plant to the best advantage. I agree with the figures almost exactly.

Peter Neff.—I am very much interested in this paper, bringing the matter of thermometers before us, and also Mr. Greene's remarks. For a number of years I have put them on machines, and I want to say, for the benefit of those here, that I have not found the opposition among the operating engineers that you would naturally expect. I found in some instances where they did not quite understand it at first, that later on they would tell me that they were running by the thermometer, and not by the gauge. I remember one instance in a brewery where they were using the thermometer instead of the gauge. On the matter of the table, I am not prepared to say that I agree or disagree. These are questions that have to be worked out.

I had one interesting experience in the use of thermometers, which goes a little further than this paper indicated. There was a plant producing probably about 40 tons of ice, and had been so for a number of years. It was put in charge of a man who did not know

much about the refrigerating machine business, but he did know something about the use of thermometers. He went into that plant and put thermometers all over it. It was not very long until he brought the production of that plant up to 70 tons a day, and he attributed it primarily to the fact that he simply made an investigation by the use of thermometers and handled the plant as it should be handled from temperature conditions. The result was unusually good in that particular instance.

I am very much interested in the discharge temperatures, but there are so many unknown quantities. Mr. Greene has expressed three, one of which is controllable. I hope, too, that someone will take the opportunity to work this out. Personally, I have done some little work on it, but I am not prepared to state just what the results will be. But if we could determine more definitely the condition of superheating over which we seem to have no control, we could get a better idea, and with the indicator be in a position to go into a plant and determine more nearly its capacity. I am particularly interested in it from the standardization viewpoint. I am glad to see this thing come up, and I certainly hope those who have testing plants will go into this matter very thoroughly, and that those of us who have a chance to do so, submit the results of practical work. This Society will be greatly benefited by such observations.

President Friedmann.—What the last speaker said about finding opposition on the part of the operating man, I believe is correct in this way; that there are naturally a great number of operating men who are very glad indeed to get knowledge. And there are also, unfortunately, a great many who have worked their way up from the position of coal shoveler, fireman, or oiler, who, as a matter of fact, will listen to all you tell them about temperatures, but think "That is all poppycock; I know how to run the machine; I don't need that." They don't make the proper response, and it stands to reason that the operating engineer who has ambition enough, knowledge enough and brains enough to understand this thing will, after a while, elevate himself out of the class of operating engineers and go farther up.

V. R. H. Greene.—I just want to say a word in answer to Mr. Neff. I think this branch of thermodynamics has been pretty well worked out. I think President Friedmann can show where this 287 and 240 degrees comes from. I believe he can prove the three things that go to make up that discharge temperature, and I would like him

to go into this question a little deeper for the benefit of us all, and shows us his results at another meeting.

Mr. Ball said the data given check up pretty well at 15 pounds back pressure and 287 degrees Fahr. That, as I say, is admitting a loss of 12 per cent. on that particular style of compressor. Now, I would like to suggest that he run it at 240 degrees and see if he cannot make a little more ice.

Thomas Shipley.—I got myself disliked a number of years ago when I criticised W. Everett Parsons, our President at that time, on the value of the indicator. I called your attention to the fact that I would not give much for the indicator if I had a thermometer. Several took exception to my remarks, inferring that I was unduly criticising Mr. Parson's paper.

President Friedmann.—Is that remark addressed to me?

Thomas Shipley.—Oh, no; but I am glad to see you are waking up, and that after all these years it has become apparent to you that thermometers are a great advantage in operating compressors. During the tests made in York by the Ice Machine Builders' Association, it was soon discovered that gauges were very unreliable. On that test we placed a row of them on one line of pipe, every gauge supposed to be a standardized instrument, but hardly two of the gauges showed the same pressure. Then we were forced to adopt mercury columns and thermometers. As you know, one pound difference in suction pressure makes a great difference in the temperature at which the ammonia is evaporating. It is all very well to say you are going to run within five or six degrees of the theoretical temperature, but first you must find out what is really the pressure. This I have never known to be obtained, except with a mercury column. In a test, gauges are near enough for the high side, but not for the low side. It is all right to make your fine theoretical arguments on the superheat, internal or external, but "The proof of the pudding is the eating," and the pudding in this particular is the handling of a certain number of pounds of ammonia gas; that is, ammonia which has done work.

It is all right for Mr. Greene to call attention to the variation from 240 to 287 degrees in discharge temperatures of single-acting and double-acting compressors, but those of us who have really tested them, side by side, know that there is such a difference when operated under the same conditions.

Now, the value of the thermometer on the discharge side is very great. It will show whether or not liquid ammonia is coming over

to the compressor. When the liquid entering with the suction gas reaches a certain amount, the temperature of the discharge gas will suddenly drop, sometimes as much as a hundred degrees, and the compressor will be operating under wet compression conditions. It is very hard to tell at what temperature this drop will take place, as there are many things which have an influence on it. If we know the actual condensing and suction pressures, we can determine within a reasonable range when this drop will take place.

This, in my opinion, can only be determined by experimenting with the individual compressor, and it is my belief that an engineer in charge of a plant can arrive at this point more accurately than by any theoretical deductions, for, if an engineer will keep a record of temperatures and pressures of both the suction and discharge side of the compressor he is operating, he will soon establish the temperature at which he must carry suction gas, at a certain back pressure, to keep the compressor operating under dry compression conditions.

As to the discharge temperatures given by President Friedmann in his paper, it is my belief that they were obtained from a plant which our company built and which Mr. Friedmann was in charge of as supervising engineer for the purchaser. This plant contained both single-acting and double-acting machines. They were run, as nearly as you can run a commercial plant, under the same conditions. The water was identical. The condensers were similar, so that there could not be a very great variance. Now, the temperatures which we obtained on this particular plant might be peculiar to it, and they certainly were; but both machines, single-acting and double-acting, were operated under the same conditions on the same system by the same men. The machines were the property of one company; hence there was no possibility for attempting any manipulation, and for the same reasons the data obtained from such tests are of the utmost value, inasmuch as they are tests made on a plant in commercial operation.

President Friedmann.—One of the things mentioned has brought home to me more forcibly than anything else that, even under the best conditions, it is necessary to give the engineer some kind of operating data. When the suction pipe is insulated or frosted over, and when the temperature comes close to the theoretical temperature, or boiling point, the engineer is absolutely at a loss to know what he has to do, because he is not able to look into that pipe to see what is taking place. But if the discharge temperature of the compressor is

very much lower than the figures given, he knows he is running liquid into the compressor and that he must take steps to prevent it.

Theodore O. Vilter.—As to the correctness of the temperatures given, I will not go into, because I don't know anything about them. But I know that if you run the compressor discharge warm, the system does better work, cools more brine, brings the brine to a lower temperature than if run colder. But I have seen plants where the compressor discharge pipe was so cold that you could freeze your fingers to it, and by looking into the conditions would find that it would make a good deal better showing with a cold discharge pipe than with a hot discharge pipe. Of course, we have to take into consideration what Professor Linde taught the Fred W. Wolf Company in this country, and that that company sent its salesmen out on the road to teach humid gas. How well that was understood by some of their customers was illustrated by a brewer who asked me, "Well, Mr. Vilter, can you run your machine also with human gas?" And I said, "Sure." Then he said to me, "Now, please explain what that young man was saying; what did he want me to know?" Then I explained to him, and he thanked me very much, and the result was that I got the contract, and the other fellow did not. The point is here ,that a great many of the Linde operating engineers have still that same idea that they must run cold, absolutely cold; frost up the pipe, and freeze up the water jacket, if there is any on it. That is absolutely wrong, and it takes a good deal of time and energy to explain to those engineers why it is wrong.

Then, as Mr. Shipley remarked to you, after it is explained and all fixed up, and you think he is going to run that way, he does not do it. He says, "What does he know? He comes in the plant and sits around an hour or two and talks about these things; what does he know about it? I have run this plant ten years; I ought to know something more about it than he does."

I had a little experience in one plant where they could not do the work desired, and they were running cold. It was in a packing house which I passed every morning and evening. I had them keep records. There were no thermometers on the discharge pipe, but one on the suction pipe. Finally, they found that, if the frost came back to the second coupling in the suction pipe, they were doing the best work. I told them to pay no attention to the suction gauge or anything else; just to regulate the frost so that it came back to that coupling, and they had excellent results out of that machine afterwards. It took me about two weeks to find it out.

Now, as to giving engineers these figures; that is all right, but I have found out by experience in operating plants that, as a general rule, you have got to shape things to the exact local conditions, and then frame up figures according to these local conditions. You can't make a universal table and say it must be done so and so, because one plant will not do the work that another plant will do. It may be the same machine. You can have three plants and put them up alongside of one another, and I am sure that they will not work alike, because there are different conditions.

E. W. Schadek.—Not long ago I was testing a plant in Texas, and I found a temperature somewhat higher on the discharge than is shown in President Friedmann's table. It was a single-acting machine and home-made. One man made it himself. Still, he got excellent results. We averaged about 18½ pounds suction pressure, measured with a mercury column, and the freezing tank produced about 44½ tons of ice, which would indicate what the conditions were. We had a higher condensing pressure than is shown on this table. We ran at about 18½ pounds, according to my recollection, and with about 278 to 282 degrees on the discharge side.

Victor H. Becker.—It is not easy for me to enter the class of prophets and teachers, but I have a very vivid recollection of a machine with thermometers which we tested in 1884, in a brewery in Philadelphia. It was a single-acting machine. From memory, I would say that it about corroborates the figures President Friedmann has put on the board for single-acting machines. We had thermometers in the suction pipe of the compressors, also in the discharge pipe, and we put a water jacket on the discharge pipe between the compressors and condenser, through which we conducted the cooling water after it had done service on the condensers. That, of course, operated as a fore-cooler for the condenser. I did this for the purpose of checking the relationship between pressure and temperature of the gas. In addition, we took indicator diagrams from the suction pipe and the discharge pipe, thus noting the relationship of the suction temperature to the suction pressure and of the discharge temperature to the discharge pressure. That I considered a better way of getting accurate pressure records than with a mercury column, which we also used. These compressors showed a very peculiar indicator card. In the discharge line, just before the closing of the discharge valve, there was a drop in pressure of four to five pounds. The compressors had 30-inch stroke, and the drop occurred in the last three inches of the stroke of the piston, and

it indicated that the water jacket on the discharge pipe was a very effective device.

I call your attention to this experience because it illustrates that, as far back as 1884, we had in mind the value of thermometers for checking the relationship of temperature to pressure on both the suction and the discharge sides; and, furthermore, it shows how nicely it did this through indicating to us the drop of pressure in the compressor before the discharge valve closed.

There was a difference of at least four pounds in the discharge pressure, and, of course, a corresponding difference in the temperature in the gas before the discharge valves closed. Which of the temperatures would you take, the higher or the lower, or the avrage of the two, in establishing the relation of the suction pressure and temperature to the discharge pressure and temperature?

President Friedmann.—Well, what Mr. Becker says is very interesting, and I think we ought to have some more data in the future.

Victor H. Becker.—I may say that this water jacket began right close to the compressor. It was in the discharge pipe, but it was very close, within four feet of the T in the discharge header of the two compressors. I afterwards installed that same arrangement of condenser and discharge pipe in East St. Louis, Ill., in a pair of machines, and we got the same result. It showed a material drop in the pressure of the compressor before the discharge valve closed.

President Friedmann.—Did you make a test, leaving the water off?

Victor H. Becker.—Yes.

President Friedmann.—Did the indicator diagram show a difference then? Did it show that drop?

Victor H. Becker.—No. That is why I referred to it as being the effect of the water jacket on the discharge pipe. Now, if that is so in the discharge pipe, why isn't it so to a lesser degree in a compressor with the water jacket?

Walter S. Ashton.—I don't know as I can add to what has been said. The arrangement of which Mr. Becker speaks, jacketing the discharge pipe, he also carried out in connection with another plant here in St. Louis, Mo, that was put up by the Empire and the Boyle companies; and that drop before the valve closed was a very noticeable thing on these 14 by 28-inch Empire compressors. The jacket got rusty and stopped up, and we discontinued it. I noticed then that that characteristic disappeared.

Victor H. Becker.—That is on the Stixel plant?

Walter S. Ashton.—Yes, on the Stixel plant.

President Friedmann.—I would like to know if you agree with this table?

Walter S. Ashton.—I do.

President Friedmann.—Or do you think it is something which is altogether unnecessary?

Walter S. Ashton.—I think it is all right, and I think if our manufacturers will use a table like that it will be a good thing. In the early days—I speak of my early days, that is, possibly 1882 or 1883—ammonia, you know, was a wonderful substance. It was a thing of deep mystery, and if I could think of some of the experiences that we went through in those days it would be very entertaining. For instance, I was instructed to pump down to zero, with the result that I shut the machines down. At that time I was employed in the Lafayette Brewery, and Mr. Nolker, the president, was very active in looking after the affairs of the refrigerating plant. He used to come and give it to me pretty nearly every morning. I was the night man at the time, and would run generally until 11 or 12 o'clock and shut down and go home; but the old man was a convivial fellow, and used to come around at all hours, and almost every morning I would get a calling down on account of that back pressure being up, and I would swear by all that was holy that I had put that down to zero, and he would swear I had not. Those of you who are here know why that back pressure was up, but it was a deep mystery at that time. That is just a little sample of what we went through to gather this practical knowledge that we possess to-day.

I would like to see someone investigate this question of pressure and temperature further, and its relations to the mechanical operation of a machine. We have such variations in our many plants that it is pretty hard to keep a line on just what to do. There are three men at each plant; that makes 33 men in control of the eleven machines during the twenty-four hours' operation, and for one man to keep track of the manner in which they handle things is beyond my capacity.

We do not go so much on keeping near the theoretical forms. As Mr. Vilter says, we observe that a certain method of operation produces the best results in the given plant, and we aim to keep just as near to that as possible.

Peter Neff.—In connection with what Mr. Becker said about the indicator action, I want to say that, with a small machine operating on a large condenser, placing it close to the condenser, with an

unusually large connection between the two, the same effect was noticeable on the card.

Roderick H. Tait.—I do not know that I can add anything to what has already been brought out. I have found, in operating plants, that a great many times the way the gas is brought back to the machine will vary largely, because of the temperature of the cylinders. For instance, there are two cylinders on one machine, or two machines on the same pipe, and one will work gas at the given temperature of the back pressure and the other will not. You can have two machines working on one system, and either of the two cylinders, or the two ends of the same cylinders, will operate under different conditions. There is no doubt that there is a relation between the temperature of the suction and the discharge, with a perfect working compressor under given conditions of cooling. We, in this country, are not used to figures like that; we generally operate a good deal higher. But I want to add to that one point about the temperature of gas entering a cylinder and being found to vary between cylinders or between machines, it was influenced largely by the design of the suction pipe.

Thomas Shipley.—I would like to supplement what I said about the heating and cooling of ammonia compressors. It would not be fair for me to sit here and hear you talk about this matter of temperature without telling you something of what we did.

In our testing we tried to run a range on discharge temperature to find out how it affects the efficiency of the compressor. We ran it from as low a temperature as we could get, with a certain back pressure, to the highest temperature obtainable, and we found that after we got away from the effects of wet compression condition; that is, where the wet compression step would be reached, we could find no perceptible difference in the efficiency of the compressor. We ran up and down a number of times, and we have prepared curves to show what the effect the temperature of the discharge has on the efficiency of the compressor. There is one thing I want to say in relation to Mr. Becker's point that he made about jacketing the discharge pipe. We found such drops of pressure where we restricted the passage of the ammonia from the compressor itself. To try this out we put a double discharge connection on a compressor, and then arranged it so we could reduce the discharge area from the compressor into the main discharge line. We found, if the area of this passage was large enough, there would not be any perceptible drop in the discharge line of the indicator card, but if you had a small

area from the passage into the discharge lines or extremely long lines, then you were liable to get the very effect to which Mr. Becker referred; in fact, it was all a question of providing a proper size discharge opening from the compressor, and discharge lines large enough to allow the gas an easy passage to the condensers.

Now, in regard to the benefit of water jackets, I wish to call your attention to the fact that, so far as our experience is concerned, the water jackets were of no use at all, except with very low pressures—let us say from ten pounds above atmosphere down.

You have the data of the Rochester tests in the records of this Society, and you will find that I gave instructions on the third day of that test to cut the water off the jackets entirely, and we ran for three days without circulating water in the jackets.

It was proven right there that we got better results after we shut off the water in the jackets than we did before. As Mr. Block said, when we made the water jacket into the boiler we did better work. The truth was, the compressors were being operated at a back pressure which did not require a water jacket.

Getting back to suction and discharge temperatures of compressors, I believe that it is policy to keep the discharge temperature down as low as you can; that is, so as to keep a dry compression condition in the cylinders. I do not believe a table can be gotten up which will cover the exact range of discharge temperature obtainable from all types of compressors, because it is my belief that each type has its own range and that the range of temperature depends upon the amount of liquid which is required to enter the compressor to produce a wet condition of operation. I believe that each type has a different minimnm temperature and possibly a different maximum temperature, both of which can be obtained without much trouble by the engineer in charge, if the compressor he is operating has thermometers in its suction and discharge connections. With these he can establish the proper range for his compressor.

Henry Vogt.—I think working by temperature is certainly a step in the right direction. In fact, we have been working with temperatures and pressures for a great many years. I do not see how we could work any other way. Conditions are irregular, and you must work according to these conditions under varied temperatures.

No. 88

PROBLEMS ENCOUNTERED IN THE DESIGN AND CONSTRUCTION OF AN AMMONIA COMPRESSION TEST PLANT.

By V. R. H. Greene, New York, N. Y.

(Junior Member of the Society.)

When the steam engine was invented one hundred and fifty years ago the theory on which it worked was not yet thoroughly understood, and during a period of a hundred years or more practically no improvements worthy of note were made in the field of steam engineering. In contradistinction to this slow development of the steam engine, we note that the history of the internal combustion engine is one of leaps and bounds towards improvement and progress. The reason is obvious: Before the internal combustion engine was built commercially by Lenoir fifty years ago, the laws governing the expansion and contraction of gases had been discovered and clearly defined. These laws served as a guide to the inventor and designer.

The practice of mechanical refrigeration is as old as the cliff-dwellers, but the science of refrigeration has as yet been but imperfectly developed. Even to-day authorities on the subject of mechanical refrigeration differ widely in their opinions regarding certain vital questions pertaining to the construction and operation of refrigerating machines.

Theory, which is based on sound facts and accurate observations, and is formulated by an unbiased mind, cannot be misleading, but will agree with practice and tend to promote progress. It is most unfortunate that so many refrigerating engineers and manufacturers of refrigerating machinery scoff at theory, and are guided only by precedent, which means old-time methods.

Realizing the beneficial effect that a more thorough understanding of the laws governing refrigeration would have upon the development and improvement of refrigerating appliances, many companies have installed model test plants at their factories, and have spared neither expense nor effort to so equip these plants that

scientific data can be obtained with the utmost accuracy. In these plants scientific tests are conducted under the varying conditions met with in refrigerating practice, with the view of gaining accurate knowledge and irrefutable data on those phases of refrigeration where theory and practice seem to differ and where authorities are at variance with one another.

In the performance of the tests, however, we find the crux of the situation; for, as the benefits are great if the plant is properly designed and operated, so are the dangers great if the plant is carelessly built and improperly regulated. False premises in a mathematical deduction will lead to amazing results in the establishment of a theory. For in refrigeration, as in logic, it is easy enough to reach the "reductio ad absurdum."

THE DE LA VERGNE TEST PLANT.

In the language of Professor Charles E. Lucke, "When the performance of any machine is the combined effect of a large number of variables, some of which can be, but often are not, evaluated, and others equally important can never be, then the solitary effect of any one may easily be misconstrued. Tests may be made with all possible honesty of intention for the purpose of proving the superiority of a compressor, but unless the problem be first analyzed to find all the really essential variables and positive care exercised to keep all of them constant, except the one under observation, the effect of that one cause can never be known. The only sure way of thus isolating a single variable is the recording of data on all the variables, the constancy of which is desired, to prove that such constancy has or has not been obtained."

In order to discuss the question thoroughly it will be easier to take under consideration a complete test plant, such as the one installed in the factory of the De La Vergne Machine Co. The compression machine is a standard 35-ton horizontal, 11½ x 20-inch compressor. When running at its rated speed of 65 R. P. M. it has a nominal piston displacement of 270,062 cubic inches per minute. This machine has connected to it three counter current ammonia condensers, each 20 feet long and 18 pipes high, having a total surface of 675 square feet. From these condensers the liquid passes into a weighing liquid receiver 12 inches in diameter by 4 feet in length, and from there into two storage tanks, each 12 inches in diameter by 4 feet in length. From these tanks the liquid passes through a liquid cooler before entering the expansion valves.

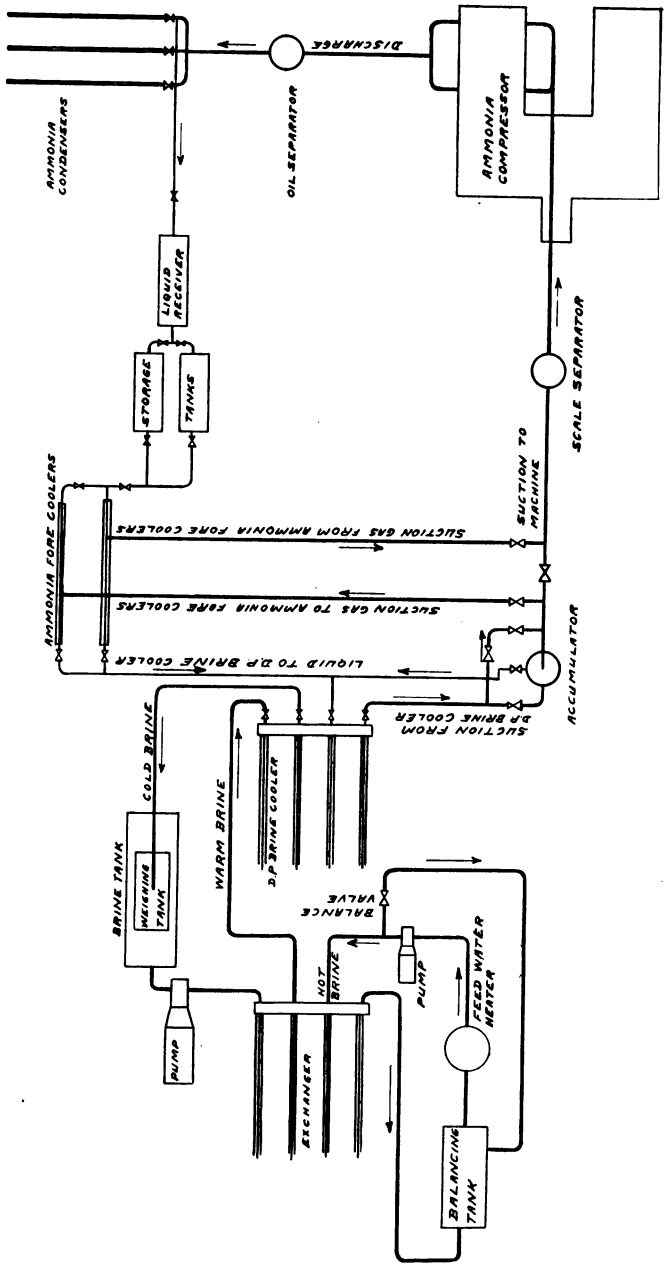
The low-pressure system consists of four double-pipe brine coolers, each 20 feet long by 12 pipes high, made of 2-inch and 3-inch pipe. In every length of pipe of both sizes brine thermometers are installed, so that accurate rates of heat transfer can be observed throughout the cooler. At the same time, mercury columns are connected at the top and bottom header of each cooler to indicate the exact friction loss.

The refrigerating load is furnished by a secondary system which passes brine through a feed-water heater, then through a double pipe exchanger and into a balancing tank, from which it is again pumped through the heater. This system is provided with a balanced valve by-pass, so that no more than a constant flow of hot brine can enter the exchanger coils, the excess passing through the by-pass valve back into the balancing tank. Because of this control, not only of the brine temperature, but of quantity passed through the exchanger, a close temperature regulation can be obtained, and, consequently, a constant suction pressure maintained.

The cold brine circulating system is of similar construction. Here the brine is pumped through the exchanger, then into the ammonia cooler, from which it passes through a "Venturi" meter into a weighing tank, falling by gravity from the weighing tank into the balancing tank, and so on to the pump suction. The plant is fully equipped with mercury columns, thermometers and revolution counters, etc.

The ammonia expansion system supplying the brine coolers may be arranged in either of two ways: first, for individual regulation by the operation of expansion valves located at the bottom of each cooler, and, second, for operation as a flooded system through a large vertical accumulator located at the end of the coolers, the bottom of the accumulator being connected with the bottom header of the coolers in the usual way, the gas returning from the coolers passing through the accumulator on its way to the compressor. In this particular plant the liquid is fed into the bottom cooler header and not into the accumulator, which is the usual practice. For both methods of cooler operation the liquid can be precooled or not before reaching the expansion valves.

The atmospheric ammonia condensers used during these tests are of the type commonly found in practice, and consist of 20-foot lengths of 2-inch pipe, 18 pipes high, the gas entering the bottom pipe and passing upward opposite to the flow of cooling water, the



EXPERIMENTAL REFRIGERATING PLANT—DE LA VERGNE MACHINE COMPANY

condensed liquid passing out through the liquid pipes located at the return bends.

The cooling water passes through a weighing tank into a Worthington water meter, then into the slotted water pipes for distribution over the condensers. Each 20-foot length of pipe has a thermometer inserted in it, and on the outside of each pipe is fastened a small cup over which the condensing water flows and into which is put a thermometer. By this means increases of water temperature can be accurately determined, as well as the temperature of the ammonia gas and liquid in the pipes.

The ammonia compressor is equipped with indicator connections, thermometers in the suction and discharge pipes, and mercury column in the suction pipe entering the compressor, the readings of which, when compared with the pressures computed from the indicator card, show the pressure drop through the valves, and, when compared with the column at the top of cooler, gives the friction loss in the suction line. The compressor also contains a thermometer in the recess in which the valves operate, which gives some idea of the average temperature of this pocket affecting the suction superheating.

The Corliss engine, direct connected to the compressor, is 17-inch diameter by 20-inch stroke, and is fitted with regular Corliss gear and necessary indicator connections. The main steam line passes through a direct separator located just over the throttle valve, and has provisions for a steam calorimeter for determining the moisture. The exhaust from the engine passes into three atmospheric steam condensers, the condensate from which flows by gravity into two weighing tanks similar to those used in boiler tests. Simultaneous indicator cards are taken from the steam engine and compressors by means of four Crosby indicators, which are arranged for electrical connections to solenoid magnets acting simultaneously on the making of an electrical contact. From these four sets of cards the friction load can be accurately determined.

SECURING CONSTANT CONDITIONS.

It is a well-known fact that many factors influence the capacity of any refrigerating machine, and before beginning any tests the arrangement of the plant must permit of a constant regulation. In the past, one of the most difficult things to regulate has been the warm brine load. Observations of previous tests have shown variations of inlet brine temperature so great as to cause the suction pressure on the machine to range anywhere within a ten-pound limit, and

this at once leads to false conclusions, as far as capacity is concerned. In the test plant in question this balanced valve in the warm brine circuit prevents any variation in pump speed from affecting the quantity of warm brine passing through the exchanger, and to insure a constant load becomes a matter of temperature regulation. The exchanger is divided into three sections, which can be used as desired. With the quantity of brine controlled by the number of sections in use, little trouble has been experienced in this direction.

Experience has also shown that fluctuations in the suction gas temperature affect the accuracy of the test data, for, if too much liquid comes back, the compressor capacity is limited; and if the return is carried too warm the effect on capacity is even more than could be accounted for mathematically by making allowance for superheat. This is probably due to the fact that this heat keeps continually increasing throughout the compression period, increasing the internal heating as well as the external. It is, therefore, necessary to keep the suction temperature constant to insure perfect results; and, of course, the best results are obtained when the gas entering the compressor is at the saturated temperature corresponding to the suction pressure. This error has been guarded against by the use of expansion valves built like expansion cocks, so as to insure proper regulation. When all these details of operation are carefully governed, values taken from indicator cards agree with surprising closeness with those of the formula for compression. If variation in the control of suction pressure and temperature occurs, the results are at once at variance with one another.

Most indicator cards taken from double-acting machines show excessive re-expansion, which is ordinarily ascribed to clearance. If the clearance volume of any compressor is definitely known, it is a simple matter to figure out theoretically what this expansion should be in per cent of stroke. Until the advent of the test plant this was never done. Now we are in a position to fill the cylinder and clearance spaces with oil and note what per cent one is of the other. With this determined, we can figure out that, with as high as 2 per cent clearance, which is larger than usually met with in practice, and between the limits of 15 pounds suction pressure and 185 pounds condenser pressure, re-expansion due to this clearance will not exceed 6 per cent. Most cards used for demonstrating purposes show expansion up to 12 per cent. Various tests have shown this to be due to the too slow closing of the discharge valve, and not to either a leaky valve or excessive clearance. This result cannot be dis-

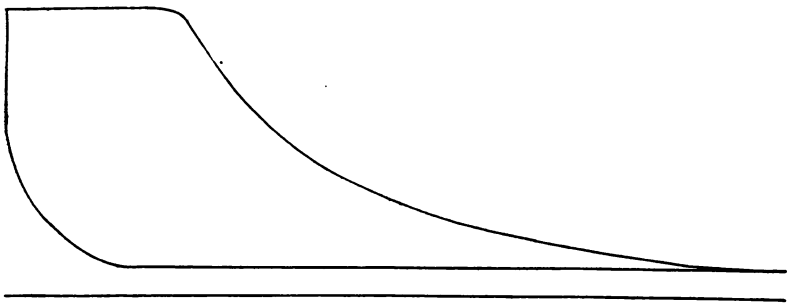
covered by plotting the adiabatic curve on the indicator card, for the reasons that, first, the indicator card is far too small for accurate determination, and, second, unless the clearance is measured as above described its exact value is never known.

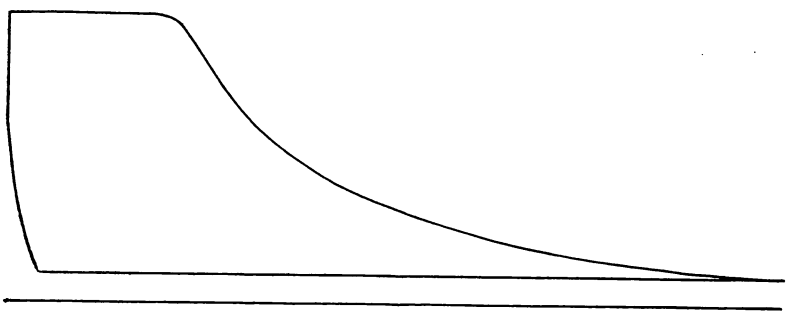
A spring strong enough to properly operate a discharge valve must require a certain tension to open it. This tension on a large valve is less per square inch than on a small one, though the total opening pressure is the same. Consequently, the springs must be carefully designed for every individual valve size.

PROBLEMS IN HEAT TRANSFER.

In modern practice one of the most difficult things to figure out is the capacity of cooling surfaces, such as, for example, double-pipe brine coolers. It is a well-known fact that the rate of heat transfer between the two mediums is increased with the velocity. Let us assume that it is necessary to cool the brine through a range of 10 degrees Fahr., the cooler to have a capacity of 15 tons refrigeration per day. Suppose we build a cooler of standard size made of 2-inch and 3-inch pipe, twelve pipes high. If, through this cooler, we circulate brine slowly enough to produce a range of 10 degrees Fahr., the rate of heat transfer through the cooler will be so materially reduced, because of the slow velocity, that the tonnage output cannot be realized. Suppose, now, we increase the cooler height to 18 pipes, in order to get the benefit of an increased velocity, and also the time of contact necessary for the required range. We might suppose that our difficulty is solved; but, as a matter of fact, our trouble is materially increased, because of the friction of the gas through the increased length of pipe.

Rates of heat transfer through a cooler based on a certain velocity, and referred to the suction temperature at the machine in order to determine the temperature difference between gas and brine, are absolutely valueless and misleading, and will never produce any results that can be checked up and accounted for. To insure accurate figures, it is necessary to obtain the exact liquid and gas temperatures at the top and bottom of the brine cooler and refer these temperatures to the inlet and outlet brine temperatures, using the logarithmical mean as the difference in temperatures, and not the arithmetical. If this is done in our previous example, we will find that in the standard cooler 12 pipes high the difference in pressure between the top and bottom of the cooler is about 4 pounds, whereas in the cooler 18 pipes high the difference is increased 7 pounds, with





INDICATOR CARDS FROM AMMONIA COMPRESSOR WITH DIFFERENT DISCHARGE VALVE SPRINGS

a corresponding increase in temperature; so that, because of the increased pressure and temperature, the degree difference is decreased in proportion to the increase in surface, and no benefits are derived from the additional height. While it is possible to procure these facts from existing plants, it is hardly feasible, and has practically never been done.

In the absence of more scientific data, it has been customary to figure the temperature of the liquid ammonia at the expansion valve as that corresponding to the condenser when determining the volumetric efficiency of any compressor. Recent tests have shown that this can never be the case, the liquid temperature being anywhere from 10 degrees higher to 10 degrees lower than that corresponding to the condenser pressure, depending upon the design of the condenser. It has proved to be maximum for the old style condensers, made many pipes high, with the gas entering at the top, and minimum for the modern counter current type. During most of these tests the condenser water averaged 76 degrees Fahr. With the water at 90 degrees Fahr., the condenser pressure was 167 pounds, and the liquid temperature at the expansion valve was 83 degrees Fahr., or 7 degrees under-cooled. This means a reduction in the number of cubic feet to be handled by the compressor per ton of refrigeration, which means a corresponding reduction in horsepower, and also a larger refrigerating capacity per revolution, corresponding to an increased volumetric efficiency. From this it becomes evident that the volumetric efficiency of any compressor is a very variable quantity and becomes valueless unless the conditions governing its operation are very closely defined.

Not least among the variables which beset the test with difficulties is the temperament and training of the engineer who performs it. Sometimes he is a pure theorist who abuses his machine, sometimes a mechanic who misunderstands his theory. Or perhaps he may be lost in the middle ground between the two. Nevertheless, it is possible to find men who can reconcile practice and theory. When the engineer knows his work, when he adjusts his machine so that all the elements are in harmony, and each is taken at its proper value, then we have the greatest instrument for the advance of refrigeration—the scientific test plant.

DISCUSSION.

Roderick H. Tait.—What is used for weighing the anhydrous ammonia, and how is it arranged not to generate gas?

V. R. H. Greene.—The receiver is six feet above the storage tanks. The main equalizing line from the condenser passes into the liquid weighing receiver, and from there into the storage tanks, so that they are all equalized under the same pressure.

Roderick H. Tait.—Is there any receptacle between the weighing tank or feed valve and the accumulator, or are there two weighing tanks?

V. R. H. Greene.—There is one weighing tank. The storage tanks are twice as large as the weighing tanks.

Peter Neff.—How are your connections to the weighing tanks arranged?

V. R. H. Greene.—They run directly into the liquid receiver, or weighing receiver, with a valve, and, coming out, separate and pass into the two tanks, so that when the weighing receiver is filled up and emptied into the storage tanks a valve is shut to allow the tank to refill. This also insures the balance of liquid in the storage tanks.

Peter Neff.—How is the receiver weighed?

V. R. H. Greene.—On a standard scale.

Victor H. Becker.—Are the two storage tanks used in alternation or simultaneously?

V. R. H. Greene.—Simultaneously.

Albert Johnson.—What is the idea of having two storage tanks?

V. R. H. Greene.—If I should let the liquid go out of this receiver into this one while this is being filled, one would empty.

Albert Johnson.—That is the only object of using two; you might use one twice as big?

V. R. H. Greene.—Yes, I could have done that.

Roderick H. Tait.—It is necessary to use them alternately? You don't feed out of the tank while you are filling into it?

V. R. H. Greene.—No; we shut this off completely and use it, then when it is filled we discharge this into the storage tanks.

Roderick H. Tait.—You weigh in the receiver or in the storage tanks?

V. R. H. Greene.—We weigh in the receiver.

Victor H. Becker.—Have you gauge glasses on all these tanks?

V. R. H. Greene.—Yes.

Thomas Shipley.—On the test plant put up at York by the Ice Machine Builders' Association in 1903 we were unable to use such an apparatus as has been described by Mr. Greene. What we did use was three drums, each suspended from platform scales, the drums being immersed in water to prevent the re-expansion of the liquid as much as possible. These drums were each connected up to the evaporating system and to the condensing system in such a manner that one of them could be opened to the condensing system receiving the liquid ammonia as it was condensed; while another could be opened to the evaporating system, to which the liquid ammonia could be fed as required. The third was in reserve, either empty or full, as required in the cycle of operation. In this way an actual record could be had of the ammonia going into the evaporating system, and also of the ammonia being liquefied in the condensing system. Plans of this system have been published too often to need further explanation. With such a system there is less possibility of error than in any method of weighing that has come to my notice. A system such as Mr. Greene describes was tried on the Cornell University plant, but I am told it did not answer the purpose.

V. R. H. Greene.—It works all right if it is equalized.

Albert Johnson.—Does the expansion into the weighing tanks cut any figure when weighing in and out?

Thomas Shipley.—No, not that we could discover.

Roderick H. Tait.—I had an occasion, a number of years ago, to look up something of that kind, although it was not a test plant. It was a job of freezing up a cofferdam that leaked between the sheet-metal piling. We drove pipes into the opening between the pilings and froze it up. The service was rendered on a tonnage basis, and in the plant the service came from we had to have receivers on scales. So we took the ammonia from the plant receivers, and for the weighing tanks we used common ammonia drums. We had to have three of them; we could not handle it fast enough out of two. We tried two to test out, but we used three and worked them alternately, cutting off one before the other was started. We had them standing close, and drained the ammonia from the plant receivers into those cylinders that were on the scales. Now, I cannot say that the re-expansion of the ammonia, as the ammonia went out, cut any figure, because we weighed the ammonia in and weighed it out.

President Friedmann.—I assume, Mr. Shipley, that your tanks

are all equalized through the condensers in some way to prevent any gas accumulated there from exerting any influence?

Thomas Shipley.—There were no equalizing connections, either between the condensers or between the drums. In fact, no connections except to the headers which led to the condensers and to the evaporating system.

President Friedmann.—Did you find that the condenser worked under those test conditions, which I suppose were normal conditions also, and would discharge in a regular way, or did it discharge intermittently?

Thomas Shipley.—It discharged in a regular way. After we filled the tank up full of water so as to keep the temperature of the drums below the temperature at which the ammonia was being condensed, we had a regular discharge, because it would naturally flow to the coldest place.

President Friedmann.—In other words, in any ordinary plant, where the receiver stands in the engine room, that might interfere with the regular discharge of the condenser?

Thomas Shipley.—To put ammonia receivers in an engine room is, in my opinion, very bad practice. They should be placed in a cold place.

President Friedmann.—A condenser, under such conditions, would not discharge regularly, but intermittently?

V. R. H. Greene.—Whether you need an equalizing line or not depends to a great extent on the style of condensers you are using. I had a curious experience along this line. The Merchants' Refrigerating Co., New York, N. Y., has standard condensers, the liquid coming out at the bottom. The liquid receiver was down in a hot engine room, and that was equalized back to the top of the condensers again. Of course, as the gas goes through these condensers there is some drop in pressure, although it is very small. There is not the same condenser pressure at the bottom as at the top. Just as soon as we undertook to equalize these condensers with the engine room receiver, we found a little higher pressure in the receiver than we had at the bottom of the condensers. When we got an equalizing line, we had more trouble than before. We found the best way was to let the gas work its way up as the liquid came down.

President Friedmann.—Taking all that for granted, doesn't it indicate that the location of the receiver in a hot engine room is faulty?

V. R. H. Greene.—Yes; no argument about that at all.

President Friedmann.—Isn't it desirable to have the receiver in close proximity to the condenser, and working under the same heat conditions as the condenser?

V. R. H. Greene.—No doubt about that.

President Friedmann.—If the liquid receiver, for any reason, on account of the local conditions, is put in the engine room, it should be insulated. And another matter I want to have on record here is that, whether it is insulated or not, it is faulty under usual conditions to put the receiver in the engine room at all. This is true whether there are equalizing pipes or not.

V. R. H. Greene.—I agree with you positively, but without equalizing pipes there is very likely to be trouble.

Victor H. Becker.—I see there are two accumulating tanks for the liquid receiver. The liquid receiver is allowed to fill, and is weighed, and after it is weighed the liquid is discharged from it into the accumulating tanks?

V. R. H. Greene.—Yes.

Victor H. Becker.—And from there it is fed to do the work?

V. R. H. Greene.—Yes.

Victor H. Becker.—Now, when those accumulating tanks are emptied of liquid they are full of gas, are they not? Then, when the liquid receiver is next emptied into those, what becomes of that gas?

V. R. H. Greene.—That is not supposed to be allowed. That is why those two tanks are double in volume.

Victor H. Becker.—That does not change the situation. They are full of gas, and the larger they are the more gas they contain?

V. R. H. Greene.—They vary from full to half full.

Victor H. Becker.—When the liquid enters, unless the gas can escape, it must be compressed?

V. R. H. Greene.—These are all equalized into the condensers.

Victor H. Becker.—Then, when the gas goes out of those accumulators into the condenser it must go back through the liquid receiver?

V. R. H. Greene.—Back from the vent in the receiver.

Victor H. Becker.—Is there a vent from this up to the condenser direct?

V. R. H. Greene.—Yes.

Roderick H. Tait.—These liquid receivers are colder than the condensers. Isn't it possible the liquid condenses into them from that gas pipe?

V. R. H. Greene.—I would not think so; on our counter-current condensers I do not see why the liquid should ever get up that high.

Roderick H. Tait.—Your liquid condenser temperature is lower than the gas coming from your equalizing pipe. Now, if they are cold enough, isn't it possible for them to act as condensers to a certain extent?

V. R. H. Greene.—The gas from this machine goes from the bottom of these condensers and works its way up and out into this weighing receiver.

Roderick H. Tait.—Regardless of where that equalizing pipe is attached, there is a gas pipe in connection with the gas space of the ammonia condenser, in communication with the receiver tanks. Now, isn't it possible, supposing this receiver is in a colder place than the condensers, for those receivers to act to a certain extent as condensers?

V. R. H. Greene.—They might under those conditions, but that would be a very rare case.

President Friedmann.—Do you shut off the equalizing valve?

V. R. H. Greene.—It is continually open.

President Friedmann.—If you left the equalizing pipe full of gas, you must condense that gas the moment you open it; is that what you mean?

Roderick H. Tait.—On the work I was talking about, it was necessary to fill the weighing tanks in the engine room. It was in winter weather, and these receivers were lying on the floor near the door where it was possible to keep them cold. They had no equalizing pipes. With the pressure of ammonia flowing in, the gas would recondense of itself at its own temperature. We had no trouble in refilling.

V. R. H. Greene.—If we did that we would have this tank under pressure, wouldn't we?

Roderick H. Tait.—Without an equalizing pipe.

V. R. H. Greene.—You don't want this to stay full of liquid. If you have an equalizing line between these two it would tend to create a partial vacuum, and it might lie full.

Roderick H. Tait.—Has it not sufficient hydraulic head to overcome it?

V. R. H. Greene.—I have known the flow to be intermittent. It will eventually come down, but it may make trouble.

Thomas Shipley.—How do you tell from your records of number of liquid cylinders how much ammonia is going into the system? Must you empty the cylinders every time to tell?

V. R. H. Greene.—Yes. I try to keep a constant level just the same as you do on a boiler test.

Thomas Shipley.—Don't you think if you had scales and took actual weight that would be more accurate? You can't tell at the end of an interval how much ammonia has come down out of the condensers and how much ammonia has gone into your evaporating system. You can't tell how much is left in the drum. On the other plant you just read it right off the beam of the scale.

V. R. H. Greene.—And get into all kinds of troubles.

Peter Neff.—I was present at the test Mr. Shipley refers to, and I know something of the conditions. I have since had occasion to run ammonia test on plants in practical operation. I have invariably used receivers on scales for that purpose, and I think the results are more accurate. Putting your ammonia receivers on scales and allow the ammonia to flow in, closing them off from the condensers, then letting the ammonia run out for use and reweighing the receivers, seems to me a more accurate method.

V. R. H. Greene.—You can weigh all three receivers.

Peter Neff.—In your case I would have each one of those receivers on a scale and weigh them after they were filled, and again after they are emptied, either entirely or only partially.

V. R. H. Greene.—Just as soon as I do that I get an intermittent flow.

Peter Neff.—Then you can use two or three receivers as the occasion demands. Three is better than two.

President Friedmann.—You mean that you would take the ammonia direct from the shipping drums, not from the condensers at all?

Peter Neff.—Take it from the condensers.

President Friedmann.—I mean if you did not, you could put the shipping drum on the scale and let a certain amount go out until you are satisfied it is what you need, and then weigh what is left.

Peter Neff.—I would prefer not to use the ordinary shipping drum for that purpose. I would want a large enough connection to let the gas push its way back from the incoming line, but you could make your connection with the ordinary drum.

President Friedmann.—You believe in weighing in and out?

Peter Neff.—I certainly do believe in weighing in and out.

V. R. H. Greene.—This is the standard boiler test method.

Peter Neff.—I think you get pretty accurate results. I don't question that, but I think the other more reasonable.

President Friedmann.—In this testing plant you have only the counter-current condenser?

V. R. H. Greene.—Yes.

President Friedmann.—And not the ordinary?

V. R. H. Greene.—No; we have only the one.

President Friedmann.—You are not equipped to make any comparative tests between the efficienecy of different condensers?

V. R. H. Greene.—No.

President Friedmann.—Is it your intention to do that?

V. R. H. Greene.—Yes; but what I am working at now is the cooler service.

President Friedmann.—A testing plant could be equipped for all?

V. R. H. Greene.—I have provisions for that.

President Friedmann.—You said that in your particular case, in what you call the counter-current condenser, you find it necessary to run the equalizing pipe. That implies it is not necessary for another kind of condenser?

V. R. H. Greene.—That is correct.

President Friedmann.—One of the questions that always arises is whether the liquid comes down or not, and if not, why.

George Berna.—You mean to keep the liquid in the storage plant just merely to have it there?

V. R. H. Greene.—Yes.

George Berna.—The storage tanks are not cooled?

V. R. H. Greene.—No; insulated.

George Berna.—They would not have any condensation?

V. R. H. Greene.—No.

Theodore O. Vilter.—In my opinion, the equalizing line ought to be cut out and the receivers ought to be cooled, because I do not think it is a definite proposition what kind of liquid is being cooled. The liquid receivers will get every bit of liquid if the temperature surroundng those liquid receivers or storage tanks, as they are called, is cooler than the condensers. I have found that out by experience, and where you have the equalizing pipe from the top of the condenser into the storage tanks you do not probably equalize it, anyhow. You can try every way under certain conditions to get liquid ammonia down into the receiver or storage tank and be unable to do it. This equalizing pipe does not do the work, because the storage tanks or liquid receivers are in a room that is warmer than where the condenser is, and the liquid doesn't like to go into a warm room.

This is illustrated in the case where most of the hot ammonia gas was discharged in the bottom pipe of a 24-pipe high condenser, and the liquid disappeared through the upper pipes. We had cross connections, and while operating the compressor the discharge was closed to the line that way, and it went in the top way and out at the bottom. While we had two receivers on the scale, we did not get more liquid, either one way or the other, nor any less, which shows that the liquid, with the cold water coming on top, went up to the top pipe and was there forced out. This equalizing pipe I do not believe in.

Walter S. Ashton.—I have found we got very fair results by having equalizing pipes.

President Friedmann.—Into the top of the condensers?

Walter S. Ashton.—Yes. As far as the gas leaving the receiver is concerned, that was illustrated during the winter time. We shut down part of the day, and when we had to start the machines there was no liquid in the receivers at all. We did not get any in there until we got a fair pressure in the condenser, and when we got the condenser heated up our liquid began to come down. We found an equalizing pipe from the liquid receiver to the top of the condensers did help.

President Friedmann.—You mean in those cases particularly where the receiver was in a warmer place than the condenser; but, on the other hand, if the receiver were located directly under the condenser, with the same atmospheric conditions, you do not think it would be as important then?

Walter S. Ashton.—I don't think it would make any difference.

President Friedmann.—In other words, if you were arranging things properly ,you wouldn't want it.

Theodore O. Vilter.—Mr. Ashton said that when he started up the machine he had to get up a certain amount of pressure, and then he forced it down. That is all right; I agree with him, but that is taxing his coal pile. If you have water at 40 or 50 degrees, you can run under low condensing pressure and you don't want to shut off the water and increase the temperature the same as the fellow did who wanted to get 150-pound pressure, so he put a steam pipe in the condenser water.

Walter S. Ashton.—Mr. Vilter did not understand what I meant. There are times when we do not require any refrigeration in our cellars at all, but we do have to cool beer. When we start up, the temperature of the engine room is 75 or 80 degrees, and outside

it is 30 degrees Fahr. Until we can equalize the temperatures between the engine room and the condensers by operating the machine, the ammonia doesn't come down in sufficient volume to do the work.

Theodore O. Vilter.—You say that you have the equalizing pipe, but the equalizer pipe does not do you a bit of good?

Walter S. Ashton.—It does not do a bit of good under the conditions mentioned.

G. A. Robertson.—We have had a little experience with receivers along this line. While none of our plants have the equalizing line from the condensers to the receivers, yet I have found it has been necessary, in order to get the best work out of the machine, to work the gas out of the receiver. I have tried both ways. I have tried to hold a little gas in the receivers, so that I could see, to satisfy myself, that there was gas going to the expansion valve, and without gas, and I have found I was not getting as good work with gas as I did when I worked the gas entirely out of the receivers. Now, our receivers are in a warm engine room, with one exception, and I think that had a good deal to do with it. Of course, I could tell by the way the expansion valves were working whether any gas was going through them.

President Friedmann.—Your point appeals to me. In every case where the liquid receiver is put in the engine room, simply to make it more convenient to the operating man, it is done at the expense of the best handling of the plant.

Norman H. Armour.—We have had some trouble in regard to equalizing pipes, but, of course, there is a difference of opinion. Some have cut out the equalizing pipes on the receivers altogether. We had a half-inch equalizing pipe from our liquid receivers to the condensers, and we found, by putting on gauges, that we had a difference of a few pounds pressure between the receivers and discharge pipe on the condensers, and we have disconnected them and put on blank flanges.

Thomas Shipley.—The only question we have before us here is whether or not in a testing plant we ought to have an equalizer on the drum. I have had experience with drums and receivers where I attempted to cool the liquid where equalizing pipe was in use, and I found I could not cool the liquid below the temperature, due to the pressure. And after I woke up I found the surface of the liquid was condensing, and gas coming down the equalizing pipe. When the equalizing pipe was shut, the liquid ammonia could be cooled, but as long as that equalizing pipe was open it allowed the gas to

come down into the receiver fast enough to prevent the cooling of the liquid. In a test where we are trying to determine how much ammonia a plant is using, there is no use of a man going into two or three decimals with the by-pass open. You might just as well have a by-pass on your brine line.

V. R. H. Greene.—I don't know exactly what Mr. Shipley is talking about, because there is no liquid going back from the equalizing line. Nobody *tried* to do any precooling before it got to the receiver. There is no argument at all.

President Friedmann.—I do not agree with you; what Mr. Shipley says appeals to me, for if there is a by-pass left open it may destroy the accuracy of the test.

V. R. H. Greene.—There is nothing in the world but a difference in temperature that will start circulation itself, and there is no possibility of getting a different temperature.

Thomas Shipley.—If the temperature of the liquid in your receiver, Mr. Greene, is less than the temperature of the liquid in the condenser, you have a current through your by-pass.

V. R. H. Greene.—How can it be?

President Friedmann.—Have you the same temperature?

V. R. H. Greene.—Absolutely.

President Friedmann.—Did you shuit off that equalizing pipe after you had a certain amount of liquid in the tank?

V. R. H. Greene.—If I did I would not be able to estimate, because you don't know what is going on inside.

Victor H. Becker.—It is an atmospheric condenser?

V. R. H. Greene.—Yes.

Victor H. Becker.—De La Vergne type?

V. R. H. Greene.—Yes.

Victor H. Becker.—The cold water goes onto the top pipe?

V. R. H. Greene.—Yes.

Victor H. Becker.—Isn't the gas in that top pipe the coldest gas in the system?

V. R. H. Greene.—I don't find a record of it; no.

Victor H. Becker.—It must be; the coldest water flows over it. Now, if the gas is colder there, because it is surrounded by the coldest water, is it not likely to condense in the equalizing pipe and syphon through into your accumulator tanks?

V. R. H. Greene.—You get different pressure as soon as it does.

Victor H. Becker.—You say these accumulators are six feet below the liquid receiver, and the liquid receiver being at least six

feet below the top of the conderser there is a difference of twelve feet Would not that establish a syphon action there?

V. R. H. Greene.—Not with a gas.

Victor H. Becker.—Your condensing water is colder than your ammonia liquid; therefore your gas in the equalizing pipe is colder than the surrounding air?

V. R. H. Greene.—You would notice it right away on the thermometers; you must have a different temperature there.

Victor H. Becker.—The liquid will travel very slowly by reason of the difference of temperature, but you maintain that the temperatures and pressures are uniform throughout?

V. R. H. Greene.—I don't say that.

Victor H. Becker.—Isn't it a fact that the liquid travels by reason of the difference in its level?

V. R. H. Greene.—Everything being equalized, it does.

Victor H. Becker.—Not by reason of differences in the temperature?

V. R. H. Greene.—The valve is shut here.

Victor H. Becker.—But the valves are open when the liquid is being sent to the evaporator?

V. R. H. Greene.—Certainly.

Victor H. Becker.—Then the liquid travels by reason of the difference in level, not difference in temperature?

V. R. H. Greene.—That is very true.

George Berna.—I only want to say that the equalizing pipe on top of the condenser is pointing upward, and there is no likelihood of the liquids running up.

Victor H. Becker.—The liquid will travel the other way—down.

Peter Neff.—I don't see what he has the equalizing lines for; he doesn't need them. I think in all test plants we should approach common, ordinary practice. Now, in a real test of a refrigerating machine we have to find the amount of ammonia being circulated by that machine. The time is going to come when we will have to make more tests than in the past, and I must say that the conditions existing in ordinary plants are different from these. As I said before, our test was made in plants in operation. We did not use by-pass connections. I believe the testing plant should conform to the conditions as you find them in the ordinary plant.

No. 89

STEEL PIPE VERSUS WROUGHT IRON PIPE IN REFRIGERATING WORK.

By P. DeC. Ball, St. Louis, Mo.

(Member of the Society.)

I have been requested to read a paper on my personal experience with steel pipe versus wrought iron pipe in refrigerating plants, and present same as a personal experience and research only, and in no wise as a technical discourse on the subject.

It is unnecessary to go into a detailed description of the production of iron, with which you are all familiar, and to follow the ore from the immense open pits in Michigan and Minnesota, where it is taken out with steam shovels by the hundreds of carloads, and railed and boated to the blast furnaces.

Wrought iron, as we understood it in our younger days, came from the puddling furnace, while the so-called steel, which, in fact is only a purer iron, is refined for making pipe skelp by the Bessemer process. The iron ore goes to the blast furnace, mixed with coke and limestone in their proper proportions, where the coke is burned at a high temperature by a hot-air blast. The limestone combining with the foreign matter in the iron ore forms a fluid, which, when cold, turns to cinder, or clinker. The iron being heavier, settles to the bottom of the furnace and is drawn off into moulds, making pigs, commonly known to the trade as pig iron, which runs from 94 to 95 per cent. metallic iron. The balance is carbon, silicon, manganese, phosphorus and sulphur, of which less than 4 per cent. is carbon, about 1 per cent. manganese, less than 1 per cent. silicon, 0.1 of 1 per cent. phosphorus, and the remainder sulphur.

To make wrought iron in a puddling furnace, the pig iron is melted—in fact, boiled—with an oxidizing cinder. The puddler, or man operating the puddling furnace, with his helper, gathers the molten particles of refined iron together in the form of a ball. The temperature of the furnace not being hot enough to melt the refined iron, which is less fusible than the original pig iron, it soon becomes like putty, and is withdrawn from the furnace, carrying a considerable amount of the cinder mixed with it.

This hot ball of iron goes to the machines and is eventually rolled into bars about one inch thick and of the width desired. These bars are cut and piled four or five feet high, reheated to a welding temperature and re-rolled into a plate of the desired gauge and width. This reduces the oxides and slag to about 2 per cent., silicon 0.1 of 1 per cent., phosphorous 0.2 of 1 per cent., sulphur between 0.01 and 0.02 of 1 per cent., with a trace of manganese and carbon, as an average for wrought iron used for making standard pipe. But, as one puddler can handle only from 400 to 500 pounds at a time, it is not of even texture, and, from the method of manufacture, there are bound to be more or less laminations when made into pipe skelp.

To make what is known as soft steel, which is only a better iron, the pig iron is taken in many times larger quantities to the mixer, instead of to the puddling furnace, melted and mixed by agitation. From there it goes to the converter, where air is forced through the melted pig. Blowing this air through the molten mass immediately causes oxidization, the silicon and manganese being first attacked, and increasing the temperature of the iron. As the temperature increases the carbon begins to oxidize rapidly, and as the iron gets hotter the change in color of the flame tells when the reaction has been effected, and the metal is drawn off and special treatment given to cause the best results for welding purposes. The slag and cinder rise to the top and the iron is drawn off into moulds, making large ingots, weighing from eight to twenty times as much as the small balls of iron puddled by hand, the characteristic difference being about as follows:

CHEMICAL DIFFERENCES BETWEEN WROUGHT IRON AND STEEL.

Wrought iron has a trace of carbon, while soft pipe steel has approximately 0.07 of 1 per cent.; wrought iron has 0.15 of 1 per cent. of manganese, while pipe steel has 0.30 of 1 per cent.; wrought iron has about 2 per cent. of oxides and slag, while pipe steel has less than 0.15 of 1 per cent. This shows that steel which is made into pipe and the pipe designated as "steel pipe" is, in fact, a purer iron than so-called "wrought iron pipe." This can easily be proved by heating a piece of steel pipe to a high temperature, chilling it suddenly in water, and then crushing it. If it has the true characteristic properties of steel, it will show them when fractured.

It is, therefore, apparent that so-called steel pipe is made from a purer iron than wrought iron pipe and, from an engineering stand-

point, is more desirable, as it is a more uniform material, easier to weld, and the finished product more regular, smoother in appearance, with no blisters, or laminations; while wrought iron pipe is not regular in quality or composition, owing to difference in pig iron used, small amount puddled at one time or in one heat, and the skill of the puddler entering into the situation, to say nothing of the laminations caused by the method of manufacture hereinbefore mentioned, which are so difficult to detect after the pipe is made. (Note Table I.)

TABLE I.

PHYSICAL PROPERTIES OF WROUGHT IRON SKELP AND PIPE STEEL SKELP.

	Pipe Steel.	Wrought Iron, Pulled Longitudinally.
Tensile strength.....	58,000 lbs. per sq. in.	46,000 lbs. per sq. in.
Elastic limit.....	34,000 lbs. per sq. in.	28,000 lbs. per sq. in.
Elongation.....	22 per cent. in 8 ins.	12 per cent. in 8 ins.
Reduction in area....	55 per cent.	25 per cent.

Wrought iron will vary from four to sixteen per cent. in elongation, whereas steel may be expected to vary between nineteen and twenty-five per cent. Puddled iron pulled transversely seldom gives 35,000 pounds per square inch tensile strength, and the elongation and reduction in area are proportionately low and variable.

The greater part of the pipe refrigerating engineers have to deal with is from two inches in diameter down, and is made by the butt-weld and lap-weld process; 1¼-inch pipe and under is butt-weld, unless redrawn.

In butt-welding small pipe the skelp or plate is heated to a welding temperature throughout, and drawn through a bell-shaped ring; the edges of the plates are forced together and welded, passed through rolls to give the correct outside diameter, and then through the cross rolls to straighten and finish. After cooling the ends are cut off, threaded and tested. As the hydrostatic test is made by blanking each end of the pipe with a tight head, laminations in wrought iron pipe are seldom detected.

Lap-welding consists of two operations: The skelp or plate is heated, passed through rolls and the edges chamfered or beveled, bent longitudinally so that the two beveled edges overlap, forming the pipe roughly. It is then heated again to a welding heat and put through the welding rolls. A mandrel, or oblong piece of cast iron,

is held in position between the rolls, so that the welding takes place on the mandrel and between the rolls, the skelp at a welding temperature passing over the mandrel, between it and the rolls. This reduces the lap where the original plate was beveled to the same thickness as the rest of the plate, and thoroughly welds it so that in lap-welded pipe the joint is approximately as strong as any other portion of the wall. While still hot it goes to the sizing rolls, straightening rolls, etc., the same as butt-welded pipe.

The steel pipe, owing to its being made from a more regular material, and of purer iron, has more ductility, and comes out a smoother finished product than the iron pipe. The following Table II. shows the average of bursting tests on steel and wrought iron pipe, of 1¼ and 2-inch diameter, furnished by F. N. Speller, member of the Engineers' Society of Western Pennsylvania.

TABLE II.

AVERAGE OF BURSTING TESTS ON STEEL AND WROUGHT IRON PIPE.

Size.	Kind of Pipe.	Length.		Number of Samples Tested.	Average Weight per Foot.	Average Thickness.	Average Bursting Pressure in Lbs. per Square Inch.	Average Maximum Stress per Sq. In. on Wall of Pipe (Barlow Formula).
Ins.		Ft.	Ins.		Lbs.	Ins.	Lbs.	Lbs.
1¼	Standard butt weld steel...	18	0	10	2.26	.139	5,808	34,600
1¼	Standard butt weld wrought iron.....	18	6	10	2.21	.147	4,891	29,800
1¼	Standard butt weld wrought iron.....	17	6	10	2.21	.136	5,283	30,900
1¼	Standard re-drawn butt weld steel.....	15	0	14	2.21	.136	7,400	44,800
1¼	Extra strong butt weld steel	20	0	11	2.86	.181	10,640	54,000
1¼	Extra strong butt weld wrought iron.....	20	0	10	2.95	.188	5.895	26,700
2	Standard lap weld steel.....	20	0	10	3.67	.155	6,645	51,000
2	Standard lap weld wrought iron.....	20	0	10	3.65	.152	3,213	25,100*
2	Standard butt weld steel....	19	0	11	3.53	.153	4,951	43,400
2	Standard butt weld wrought iron.....	17	6	10	3.70	.156	3,687	28,600
2	Tubing (4-lb.) lap weld steel	21	6	10	4.26	.178	7,361	47,800
2	Extra strong lap weld steel..	18	6	10	5.01	.218	7,909	43,300
2	Extra strong lap weld wrought iron.....	20	0	10	4.79	.206	6,349	36,500
2	Extra strong butt weld steel	20	9	10	5.06	.220	7,661	41,700
2	Extra strong butt weld steel	20	6	10	4.91	.213	8,238	45,900

* Purchased as lap weld but looks like "butt weld."

We have found from personal experience that steel pipe is threaded or chased as readily and perfectly as wrought iron pipe, provided the dies or cutters have the proper rake. Dies for threading wrought iron pipe require much less rake, only about 12 degrees,

than dies to chase steel pipe, which, to get best results, should have about 18 degrees rake. It, however, requires approximately 6 per cent. more power to thread steel pipe when proper dies are used. As, however, the torsional strength of steel pipe is much greater than wrought iron pipe, there is much less danger of twisting steel pipe or opening the weld during the process of threading.

PRACTICAL EXPERIENCE GAINED.

We have now to consider the resisting qualities of the material to corrosion; of wrought iron, with its laminations and slag, and soft steel, almost a pure iron, regular in quality and composition. Our personal experience covers since 1878, when only wrought iron pipe was made. It was of various sizes and thicknesses, depending upon the mill it came from, some large outside, others small; sometimes, especially in the case of larger pipe, with blisters inside, caused by laminated skelp.

In ice-making and refrigerating brine tanks, where the pipe was at all times submerged in brine, this pipe gave no trouble from pitting or corrosion, but, especially in submerged condensers, we noted heavy pitting in spots. The conclusion we came to in the later 80's was that this effect was the result of galvanic action, the metal being positive, and the mill scale or slag negative. This conclusion was borne out later by the tests of the Bureau of Steam Engineering of the Navy Department.*

In our personal experience we have never known submerged pipe, iron or steel, to corrode in an ice tank or brine tank to an extent to cause trouble, and we have taken out coils in these tanks after fifteen years' service, both iron and steel, and used the pipe in making new coils. This does not apply where the practice is to expose the pipe for several months in the year to the oxidizing effect of salt, air and moisture, as is done in some plants.

The surface or open-air type ammonia condensers is of necessity exposed to all kinds of corrosive effects—air contaminated by all kinds of gases, sulphurous included, water containing all kinds of minerals, and heat and cold. We as yet have been unable to find wherein steel pipe is not as good as, or better, than wrought iron pipe, and we believe that each particular case of corrosion is caused by some set of local conditions, such as stray electrical currents or contaminated air or water.

We have found as high as 30 per cent. of genuine wrought iron

* See *Journal of the American Society of Naval Engineers, May,* 1904.

pipe defective, but never more than 7 per cent. of steel pipe, the average amount of steel pipe defective at 500 pounds air test under water being less than 2 per cent., and this defect generally resulted from too great economy at the mill in cutting the pipe too near the tong end.

Iron pipe, when it runs bad, runs very bad. This, I think, is caused by the large variation in quality of material, especially as now it is the practice to use steel scrap of varying composition, so that the slag is not always uniformly distributed. I call to mind a case where the pipe made up into coils and tested under water showed many leaks from end to end, sometimes in the center only. The pipe was so bad we sent a portion of it back to the mill, and had a sample tested to see if it really was wrought iron. It was wrought iron, and the mill replied, stating they had tested the pipe to bursting and could find no leaks in it. We again tested other pieces which leaked, and the same leaks developed. We then had a man come from the mill to see this pipe tested. Some of it leaked so badly it blew the water out of the testing tank. We then tested the pipe, as is done in the mill, by blanking each end, and the pipe was absolutely tight. Upon close investigation we found the iron laminated, the air going into the laminations in the wall of the pipe at the ends, and coming out through many holes caused by slag and other impurities in the center of the length. When this pipe was screwed up into fittings it necessarily leaked badly. When the ends were blanked off and the wall of the pipe sealed at the ends, as is done at the mill, the pipe showed tight. You can imagine what this would do if the mill had galvanized this pipe, the spelter soldering over defects in the center of the pipe, and therefore showing no leak under air pressure. But the ammonia, which would soon eat out the spelter, would certainly give the engineer, as well as the contractor, trouble.

Galvanized steel pipe, owing to the uniform quality of material, absence of slag and laminations, is an ideal material for ammonia condensers, while galvanized iron pipe for the same purpose is a trouble-maker, for the reason that the pipe is pickled or cleaned in hot sulphuric acid, that eats off the mill scale and any slag it can find, and sometimes into the interior of the pipe. (This is then galvanized, withstands the air under water test, made up into condenser stands, erected and put into operation.) When the ammonia decomposes the spelter, with which the pipe was galvanized, the leaks begin, and the engineer's troubles also begin at the same time.

Last year we took down, moved and rebuilt an open-air am-

monia condenser which had been in operation fourteen years, and which was made of steel pipe of full card weight, not galvanized. The pipe was in absolutely perfect condition, neither pitted nor corroded at all. In fact, it looked as good as after the first three months' run.

From thirty-three years of personal observation, constructing, erecting and operating ice-making and refrigerating machines, of both absorption and compression types, using iron pipe for the first fourteen years, and iron and steel pipe for the next nineteen years, we are convinced that local conditions only govern the corrosion of pipe in refrigerating and ice-making machines; and that chemically and mechanically, mild steel pipe meets the requirements of the refrigerating engineer in all respects, better than any other pipe, for the reason that it is superior in point of finish, strength, strength of seam, and uniformity of material.

We think we are borne out in our conclusions by the fact that our understanding is that more than 90 per cent. of all tubular goods is to-day made from mild steel; and that the specifications for "genuine wrought iron pipe," which some purchasers of refrigerating machines require, necessitate a careful, personal supervision of the contractor or his engineer to see that his contract is fulfilled as specified.

DISCUSSION.

Theodore O. Vilter.—I have had a little experience on this very same pipe proposition. Mr. Ball has mentioned the buyer who buys cheap pipe. I have been through iron pipe mills, and I have been through steel pipe mills, and salesmen would tell me that their pipe was tested to 1,200 and even 1,500 pounds pressure. I told them that I could not believe them. They invited me to go to the mills and see it tested, and I actually did see that pressure on the pipe, and I saw more than 1,800 pounds in one case. But the proposition is that the water is shot into it, and if the pipe doesn't burst it is all right. That is their test. That test does not interest the refrigerating machine man in the least. I told them to put up an air-testing plant, and that the pipe for the refrigerating man should not be tested with water at all. If they would put in an air-testing plant, with a 300-pound pressure, that would be all that we would require. The next thing was, "Well, that is going to cost a whole lot of money, and we can't get the appropriation." I said, "Send me a car of pipe without testing it with your water pressure, and I will tell you what I find out. I will test every length of it with

air pressure." I did that, and there were only three lengths of pipe that showed little pinholes; the rest of it was good. The mischief is done when they shoot that water in and it gets into the porous places. It takes three weeks to get the pipe to the shop, and it begins to rust; then it lies around the shop for three months or six months, and it rusts still more. Then it is made up into coils, and we get it under air pressure and find it absolutely tight. Then it goes to destination and is tested again by our erecting engineer. He puts in the ammonia and operates it thirty days, and everything is tight, as it should be. Two or three months later we get a telephone or a telegram, "Hurry up, the ammonia is leaking out of the system." And, of course, we go right away and put on a rubber patch, whereupon that rubber patch is advertising us until we have a chance to take that piece of pipe out. Think what it costs! It isn't very much for Mr. Ball to go over to East St. Louis, but suppose I go from Milwaukee to New Orleans to put in a length of 2-inch pipe!

It is really necessary for machine manufacturers to get together on this proposition and tell the pipe mills that if they put in air-testing systems we will buy their pipe, and if they don't we'll not. We ought to get together as much as possible and put in such an air test plant. The consulting engineer, I find, also agrees with the customer who buys it, often asking for a poor grade of pipe, and we are just as innocent as a new-born babe. We want to furnish a good grade; we want to establish a good name, and we can only establish that name by furnishing the best material.

Only the other day it happened, not with pipe, but with a plunger for an ammonia compressor that was sold to us as chrome-nickel hammered steel. It was two inches too long, so the lathe man went to work to cut it off, and we found a hole in that plunger that I could slip a pencil into. These are the things we run up against; and while we know that we have to contend with such conditions, the customer that buys our machinery doesn't give us one iota of consideration. That is where the thing is wrong. The owner of such a plant should be told; and if he engages a consulting engineer, should be told by that engineer that that doesn't mean anything; that the manufacturer will make it all right, which he has to do, anyhow.

President Friedmann.—Mr. Vilter, would your idea be that, instead of specifying, let us say, wrought iron pipe, you would leave that part to the contractor and simply specify the weight per lineal foot? Would that suit you better?

Theodore O. Vilter.—Well, in my opinion, and it is also my experience, that sometimes we get a carload of pipe which is strictly first-class wrought iron pipe without a blemish, and then, again, we get a carload of strictly wrought iron pipe of which only about half of the lengths can be used.

President Friedmann.—In other words, you agree with Mr. Ball that it is an unreliable material?

Theodore O. Vilter.—It is an unreliable material.

President Friedmann.—You would prefer to take soft steel or any kind of steel?

Theodore O. Vilter.—I do not care whether you call it steel or iron. Give me a uniform material. A uniform material is what we want for this business.

President Friedmann.—According to this paper, the only uniform material is steel.

P. DeC. Ball.—There is no wrought iron that is uniform.

Theodore O. Vilter.—If you specify wrought iron pipe, will they pay any attention to it?

P. DeC. Ball.—Some of the mills roll their names into it for the benefit of the customer.

V. R. H. Greene.—I don't know that I can talk intelligently on the subject of steel and wrought iron, because it is not very often that you get a chance to compare them. My experience has been with galvanized steel and iron, but that is a later issue in Mr. Ball's paper, and I would rather wait until you get this steel and iron pipe question threshed out. So far as I know, it is very difficult to tell whether you are going to get wrought iron or steel pipe. I mean the difference lies in the manganese contents. We got a carload once that acted very peculiarly, and did not seem to cut right. We guessed it was steel and not wrought iron, and that the mill was trying to run in something on us. We had it analyzed, and the report came back that it was undoubtedly steel pipe. We said: "If you are absolutely sure that it is steel pipe, that is all right. We don't want to take it up with the mill unless we are sure." As soon as we told the chemist that, he said: "I don't know; it is pretty difficult to tell." So we never came to a conclusion whether we had steel pipe or iron pipe. We have tried to analyze all our pipe. It is very difficult, in these days, to tell exactly what we are working with. The pipe men claim they can tell by the way it acts, but that is only a crude way of getting at it.

P. DeC. Ball.—I beg to differ with Mr. Greene as to the only

difference between wrought iron and steel being in the manganese. The practical difference is 2 per cent. slag, which causes the trouble. No one can tell from observation as to steel or iron pipe. The only way to tell is to analyze it or use the acid test.

President Friedmann.—Mr. Greene, would you care to state what, in your experience, would be the best pipe material; in other words, if it were left entirely to you to select any pipe you want, what would you take?

V. R. H. Greene.—My experience is that I have yet to come across an ice plant which is not extremely damp, and that always means a certain percentage of electric leakage. You find grounds on every side. Now, electrolysis is noticeable on steel pipe, simply because of its purity; whereas if you take a properly puddled iron pipe, the slag should tend to surround those different strands of iron and to a certain extent protect it from the electricity. I do not think there is any question about the tensile strength of steel being far greater than iron, and for that reason alone it might be considered to be far better pipe, but when it comes into the path of electric action, then I am afraid you are going to notice a difference between the two.

President Friedmann.—In favor of the wrought iron?

V. R. H. Greene.—In favor of the wrought iron; yes. At the Merchants' Refrigerating Co. we had a 500-volt trolley service from the Public Service Corporation, and we always carried about 450 volts ground. You could see pit marks on the pipe as the water flowed over the outside. We got rid of that by grounding that pipe with a water connection, so as to furnish a freer path for electric current and avoid its passing through the pipe itself into one ground. In that particular plant we always specified wrought iron pipe, because we felt that we could absolutely depend on its lasting longer. I think that is an extremely difficult condition to fight against.

P. DeC. Ball.—If you had gone further, you would have found the wrought iron pitted deeply in places, while the steel pipe pitted uniformly over the entire surface.

Thomas Shipley.—We use pipe from the Reading Iron Works, Reading, Pa., and it is supposed to be iron pipe. Now, I never went into the matter closely enough to know definitely. It is very uniform pipe, and we do not have any trouble, and we are not looking for trouble.

President Friedmann.—In other words, you use strictly iron pipe, and think it preferable?

Thomas Shipley.—Yes. We have not found many of the troubles that Mr. Ball seems to have run against. We have had no trouble with the pitting of the iron pipe. We have had trouble, however, wherever we tried steel pipe, and in one case particularly, in New York City, we had to pull out the whole freezing system of a sixty-ton plant, where we took the mill man's word for it, and put in steel pipe. Steel pipe may have improved since then.

P. DeC. Ball.—Have you ever tested it to see whether it was iron or steel?

Thomas Shipley.—Yes; we tested that particular lot, after which I gave orders not to buy any more steel pipe, and I haven't rescinded that order.

M. B. Smith.—For the last six years I have been making a special study of the corrosion of metals, especially in brine distribution. I am inclined to think that it is the purity of the metal, rather than whether it is wrought iron or steel, which will eventually decide the rate of corrosion. Practically all of the impurities in iron act negatively electrolytically toward iron; wherever you have a metal negative toward iron, you hasten dissolution of the iron. Other influences, such as the presence of air or any oxidizing condition, will then throw that iron out of its medium as rust, and that means a loss of metal. If the impurities are scattered homogeneously throughout the metal, that attack will take place in a different manner; that is, we will not have any very severe pitting. That, I believe, is a common property of steel, and not of wrought iron. The wrought iron which we commonly get on the market is full of slag. Slag unquestionably acts negatively toward iron, and therefore will hasten dissolution of the iron. In the case of ordinary wrought iron, the attack will be in the nature of severe local pitting. In the case of good steel it will be an even attack. The leakage of current from electric circuits around the building of various types, no matter whether it is direct current or alternating, may be disputed on that statement; but we have made, within the last two years, experiments with both direct and alternating currents, and we find there is no appreciable difference if the experiment is carried on over a sufficient length of time. The direct current gets in its work more rapidly than the alternating current. By that I mean the attack is accelerated at the start, but the alternating current soon catches up. We find, also, that the lower the rate of alternation, the more rapid the attack; that is, as the alternation becomes

slower, you are approaching more nearly the condition of a reversing direct current.

Speaking about galvanized steel and galvanized iron makes me think of an experience I had a week ago in one of our Eastern cities, where they had put in galvanized wrought iron. In another part of their system they had steel which was galvanized, and so long as the zinc was present it undoubtedly exerted a protective effect on the iron; but as soon as the zinc went, which it did, especially wherever the galvanized iron engaged a dissimilar metal such as brass, then the iron went very rapidly in the case of the wrought iron, and much less rapidly in the case of the steel.

Now, I believe that that is due to the presence of impurities in the wrought iron, and also due to the fact that in making up joints a strain is induced in the piping at the threads. Anyway, the point that I am trying to bring out is that local conditions, such as the presence of stray currents and the presence of air in the brine pipes or in the brine itself, the brine being saturated with air, and the existence of undue strain at the threads in the piping, are conducive to rapid attack upon the metal.

W. H. Bower.—We have been interested in this question as distillers of ammonia and handlers of ammonia in large quantities, and we have found corrosion in different conditions, just as has been stated, in pits and in spots, and regularly distributed all through either a sheet or a pipe. We took the matter up five or six years ago, and we have come to the conclusion that it is not so much the difference in potential of, say, joining a wrought iron pipe to a steel pipe, unless there is a third metal there, such as zinc in galvanized or cast iron fittings, malleable fittings and steel or wrought iron pipe, as the structures of the metal itself. That varies, especially in steel, as to how it has been treated in regard to heat and stresses, how it has been rolled, and the temperature of annealing. This has now been practically confirmed by a report that has just been issued by a committee appointed by the British Association for the Advancement of Science. They made their first experiments on steels containing variable amounts of carbon, and have given the result in this very interesting technical report. For instance, the members speak of the perlite in the steel being laminated and granulated and emulsified, and such terms as that. But the fact does remain that in a steel containing a certain amount of carbon after certain heat treatments, the perlite constituent will change in its electrical posi-

tion; that is, instead of being electrically negative it will become electrically positive.

The chances are, I think, that in the very near future we will not ask simply for steel pipe or wrought iron pipe, but order according to the conditions under which we know the pipe is going to be used. We will order pipe that is made under certain heat treatments, with a certain percentage of carbon, and specify that it has not been heated in annealing beyond the range of the arresting point. I think, from the experiments that have been made by the British association, there is no doubt but that we are on the eve of a great discovery, so that probably iron or steel can be used in almost all manufactures with all corrosive chemicals.

A point that has not been brought out is, that, when under strain, steel is much more liable to corrosion from electrolytic action than when it is not under strain. For instance, a steam coil under pressure will corrode when placed in a solution of ammonia, and it will corrode on the inner side, while the outer portion of that coil will be practically intact, showing the difference in potential between the strained and the unstrained part of the steel. I have a very beautiful sample of that in my office.

I think that probably not enough care is taken in the building of tanks from sheet steel. When the steel is cold punched, there is a strain set up wherever the punching takes place, and the structure of the steel is changed. To get a good, serviceable hole for tapping or for riveting, it should be reamed. All the loose edges should be taken off.

The report of the British association that I have here is entirely too long to read, and, as I said, too technical, but I want to say again that I believe we are on the eve of a great discovery in the structure of steel and iron. As to the definitions of steel and of iron which have been given here, the latest one I have heard is that wrought iron is a metal which is made in a plastic condition; steel is a metal which is made in a fluid condition.

President Friedmann.—Mr. Vogt, under the conditions that Mr. Bower has mentioned, what do you find taking place in your machines?

Henry Vogt.—We use wrought iron pipe exclusively. We have been using it ever since we have been in business. We have tried steel pipe a few times, to our sorrow. I would say, however, that I do not think we get the iron pipe now that we did fifteen or twenty years ago. I am no metallurgist and cannot give any particular rea-

sons, but we use iron pipe because we believe it is less liable to corrosion.

President Friedmann.—What is the reasonable life of a pipe under ordinary conditions in a refrgerating plant? Mr. Ball said, if I am not mistaken, that he had pipes in for fifteen or twenty years which came out all right.

P. DeC. Ball.—I say that either iron or steel submerged in a brine tank, and not exposed to the atmosphere, will last indefinitely —twenty to thirty years.

Henry Vogt.—I will say, Mr. Chairman, that steel under heat is certainly, in our experience, much more apt to corrode than iron. That has been our experience, and that is why we use iron exclusively.

President Friedmann.—Well, it leaves the question, in my mind, a little open yet. We hear opinions on one side where wrought iron is preferred, and on the other side where steel is preferred.

P. DeC. Ball.—If you have always used wrought iron, how did you get your experience with steel, Mr. Vogt?

Henry Vogt.—We have tried to use it. You did not pay attention to what I said before. We have tried steel pipe, to our sorrow.

P. DeC. Ball.—Is it fair to ask where you buy your pipe?

Henry Vogt.—Reading Iron Company.

P. DeC. Ball.—Ever have it analyzed?

Henry Vogt.—We have had chemists analyze it occasionally.

P. DeC. Ball.—Do you know how the pipe is made?

Henry Vogt.—No. I could not answer as to chemical analyses.

J. S. Louis.—For the last sixteen years, with the exception of three times, when, owing to strike conditions, we were unable to get it, we have used pipe from the Reading Iron Company. Those three times I bought pipe from other mills. In one case I bought steel pipe from a mill, and it was guaranteed as being just as fine, or finer, than Reading pipe. The mill men admitted that Reading pipe was pretty fine pipe. I sent over a carload of it back. At a later time I bought another make of pipe, owing to the fact that the customer had specified that particular pipe. We tested the pipe, and three carloads of it leaked, and I had to send it all back and substitute Reading pipe. So, like Mr. Shipley, I believe in letting well enough alone. I don't know whether Reading pipe is made of iron or not. They swear it is made of iron. It may be made of brass or alloy; but it is a fine pipe, and it has given us excellent service, and there is a very small percentage of it that leaks. We give it the

air test. I think, however, that some of the pipe that is produced is damaged in the very high hydraulic pressure that is given at the mill. I think it is ruptured, and then, when the air test is put on, it is liable to leak.

President Friedmann.—According to that, it would be wrong in any case to have the manufacturer use the hydraulic test on the pipe?

J. S. Louis.—An internal air test is much better than a hydraulic test. A 300-pound air test is much preferable to a 1,200-pound water test. I think a great deal of the testing done at the mill is more or less careless. I have watched pipe tested at the mill, and while some of it is put to a very heavy pressure, the cheap labor employed for that purpose allows some pipe to go through without the necessary testing.

P. DeC. Ball.—Testing with air would be dangerous if the pipe were not tested hydrostatically first, in cases of very defective pieces, and would be likely to kill somebody. A piece of pipe might hold for a while and then go to pieces with the 300 pounds on it. I think the manufacturers desire the water test first.

President Friedmann.—Up to what pressure?

P. DeC. Ball.—Oh, a reasonable pressure—500 pounds.

W. H. Bower.—I have just gone over the matter with the National Tube Company, spending about two years on testing specifications for anhydrous ammonia cylinders. In buying them we supposed they were tested to about 1,500 pounds, and so they were, but the permanent expansion was not measured at all. We might get a cylinder that had been ruined by having 1,000 pounds put on it. So now we buy our cylinders with the specification that the permanent expansion shall not exceed 10 per cent. of the apparent expansion under 1,000 or 1,500-pounds pressure.

J. S. Louis.—The question will probably be considered leading, but I would like to know if Mr. Ball will name the mill at which the pipe to which he refers was tested.

P. DeC. Ball.—The pipe was made at three different mills.

J. S. Louis.—All the same company?

P. DeC. Ball.—The steel pipe was made at one mill, and the two samples of wrought iron pipe were made by two different mills not owned by the other. You gentlemen have mentioned all the names among you.

No. 90

COLD STORAGE LEGISLATION—STATE AND FEDERAL.

By R. H. Switzler, St. Louis, Mo.

(Non-Member of the Society.)

Two years ago, or thereabouts, public agitation over the high cost of living, and the resultant groping for the causes thereof, brought the cold storage industry into the public eye. The storage and preservation, by mechanical refrigeration, of products entering into the daily food of humankind had been instituted, developed, and brought to a remarkably high standard of perfection, during a period of approximately twenty years, without attracting any particular public notice; the average man of intelligence having little or no knowledge of the methods or extent of the business, or of any of its essential facts. During the course of the public search for possible causes of the increased cost of living, some amateur economist suggested the cold storage warehouse, with immense stores of human food "locked up from the consumer," as a powerful contributory cause of high prices. The press, ever ready for something new, leaped at the idea, the full limelight was turned on the alleged iniquities of the cold storage warehouses, and the reading public fairly inundated with misinformation and half-baked conclusions on the subject. We all know the rest. Legislators of every rank—municipal, state and federal—felt called as tribunes of the people to introduce measures to curb this "monster of oppression" which, according to the papers, had grown up among them, and a wave of restrictive legislation passed over the country from ocean to ocean.

It is not my purpose here to argue the cause of the cold storage warehouse, or to point out its importance as a factor of domestic economy; this were indeed superfluous before so enlightened a body, whose members have been so intimately associated in the progress and high development of the cold storage industry. Nor is it necessary or timely to point out the misinformation spread abroad by the press, or to dwell upon the absurdities and fallacies in many of the bills introduced into municipal assemblies, state legislatures and the halls of Congress. These are matters of common information among

all who are here assembled. The purpose, rather, of this paper is to review briefly the present status of state and federal legislation on cold storage and the defensive work being carried on by the industries affected.

Attempts at municipal legislation to restrict the operation of cold storage warehouses have failed of results, the authorities of the cities having been quick to see that the cold storage question, involving, as it does, a broader phase of commerce, is more properly within the province of state and federal authority. Restrictive bills introduced into various state legislatures, with the exception of four states, have also failed of passage.

In California, Indiana, New York and New Jersey cold storage bills have been enacted into law. In Colorado, Delaware, New Hampshire, Missouri, Ohio and Pennsylvania cold storage bills were introduced, but were either killed by adverse reports from the committee having them in charge, or died with the adjournment of legislatures without consideration. In Illinois several bills were introduced. Only two were reported out of committee, with three or four others ready to be put forward in case the first bills were defeated; the two, however, had not been reached at the time the legislature adjourned, and hence remain to be taken up at the next session in 1913. In Massachusetts none of the bills presented were passed, but instead a state cold storage commission was appointed to investigate the subject thoroughly and report its recommendations for regulating the cold storage business to the next legislature. This commission is now investigating the subject. In Wisconsin there was no restrictive legislation; on the contrary, a resolution was introduced presenting a memorial to Congress asking that the time limit in the pending federal legislation be made not less than one year.

STATE LAWS IN FORCE.

In the four states which have passed cold storage laws, those of Indiana, New York and New Jersey are similar in their general provisions, while the California law is a mild statute, simply requiring that eggs and butter from cold storage must be sold as such, and requiring merchants who offer cold storage eggs and butter for sale to put signs in their windows indicating that fact. The Indiana law names a nine-months' limit of storage, requires stamping of cold storage products, with the dates in and dates out of storage; puts the enforcement of the law upon the State Board of Health, with power to name such regulations as may be necessary to secure en-

forcement, and requires cold storage warehouses to be licensed by the State Board of Health, with power in the Board to revoke licenses. Eggs which have been in storage thirty days shall be marked "Cold Storage" when offered for sale, and no cold storage food products from which the cold storage dates have been erased may be offered for sale at all. First and second offenses are punishable by fines, and a third offense by fine and imprisonment. The State Food Commissioner and his deputies are burdened with the responsibility of keeping watch upon cold storage products offered for sale, a provision likely to prove a serious hindrance to the effectiveness of the law. The New Jersey and New York laws are very much the same; both provide for labeling, and both fix time limits of ten months, with the exception that in New Jersey foods may be kept longer than ten months by special permit from the Board of Health. In New York an exception is made of butter, on which the time limit is fixed at twelve months. Both states prohibit the transfer of cold storage foods from one warehouse to another for the purpose of evading law, and prohibit the return to cold storage of any food product after it has been released therefrom for the purpose of sale. In New Jersey the first offense brings a penalty of not to exceed $500, and the second offense is a misdemeanor; violation of the New York law is a misdemeanor, with no penalty fixed. In New Jersey, power to enforce lies with the Board of Health; New York invests the State Commissioner of Health with such powers.

The boards of health of New Jersey and New York have recently issued tentative regulations for the proper enforcement of their cold storage laws. Both define cold storage goods as food products kept for more than thirty days in a temperature below 40° Fahrenheit, but exclude from this classification any goods which may be kept at low temperatures during the process of manufacture; both boards require that goods offered for cold storage must be enclosed in boxes, barrels or other stable packages, unless the goods are of such character that containers are impracticable. In New Jersey, packages are to be marked simply with the date received in storage in figures ⅜ inches high; in New York, the package or article must be marked in figures ⅜ inches high, with the name and location of the storage company, with the words "Cold Storage," with the word "Received" and the corresponding date, and the word "Delivered" and the corresponding date. In New Jersey, goods held for less than thirty days are not regarded as kept in cold storage,

but must be held in rooms separate from the regular cold storage products; also undated goods from other freezers may be received, after being inspected and passed by the state board of health; and, further, requests by owners to carry certain goods beyond the ten months' limit must be made to the Board of Health and satisfactory reasons given, whereupon the Health Board will make inspection and give answer. The New York regulations require that cold storage warehouses shall be kept clean and in a sanitary condition, and no person with a contagious disease may be employed.

California, Indiana, New York, and New Jersey, therefore, are the only states where cold storage laws are now in operation. The California statute is simply an effort to have cold storage goods sold for what they are, a state of things long wished for by cold storage men. In Indiana, the provisions for enforcement are apparently so cumbersome that it will be difficult to render the law effectual.

New Jersey and New York are the places where real cold storage laws are being tried out. In New Jersey there seems to be a recognition of the fact that cold storage men want to regulate their business according to the law and adjust themselves to the new conditions as readily as possible. In New York, apparently, there is some zeal for prosecution, and the authorities up to this time seem more interested in catching some unversed storage man in a technical violation of the regulations than in showing him how to comply with the laws and thus secure better conditions. For obvious reasons, the operation of the New York and New Jersey laws and their effect on the business is being watched with absorbing interest by all cold storage men.

PROPOSED FEDERAL LEGISLATION.

The federal legislation consists at this time of two bills before the House of Representatives and one before the Senate, their general provisions being largely identical. The House bills were referred to the Committee on Interstate and Foreign Commerce and, as far as is known, received no consideration, owing to press of other business. In the Senate the bill introduced by Senator Heyburn, of Idaho, was referred to the Committee on Manufacture, of which Senator Heyburn is chairman. This bill is a revision of a similar bill which was reported favorably by the same committee at the end of the prior session of Congress, but not voted on, and was reintroduced by Senator Heyburn at the beginning of the recent special session.

This bill (N. S. Senate 136) defines cold storage to mean any receptacle where, for a longer period than ten days, food products, except when actually in transit, are kept by mechanical refrigeration at forty degrees Fahrenheit or below; it provides that no foods shall be placed in cold storage unless in sanitary condition, and requires all cold storage goods to be labeled with the essential dates; fixes time limits on various classes of food products carried in cold storage of from three to seven months; prohibits the return of goods to cold storage after having once been removed; prohibits any manipulation to make cold storage foods resemble fresh foods, and provides that food products frozen in cold storage must be sold in the frozen state. The President of the United States is empowered to make rules and regulations for the enforcement of the act, and penalty for violation is a fine of one hundred to five thousand dollars and imprisonment for from six months to five years. The law is made applicable to the Districts of Columbia, Territories, Districts and Insular Possessions of the United States and to food products entering into interstate and foreign commerce.

This is the bill upon which attention has been centered up to this time. It is a matter of public knowledge that cold storage warehousemen and affiliated industries have made a joint effort to resist the bill, and to do so by putting before the Senate the real facts concerning the methods, operation, extent, and importance of the cold storage industry to the food supply of the nation. A joint committee, representing cold storage warehousemen and affiliated industries, has been directing this movement, and, through their efforts, complete and valuable testimony has been placed before the Senate committee. The published hearings before the committee, now available in pamphlet form of some five hundred pages, show the testimony to have been practically unanimous in condemning the provisions of the bill. Shippers, dealers and handlers of perishable products in large numbers, representing every section of the United States, in every trade and industry affected, testified before the committee, showing their dependence upon the cold storage warehouse, and declared that if the bill, with its proposed provisions, should be enacted into law, it would mean ruin to their business. They further stated unequivocally that the food products of the country could not be properly handled without cold storage facilities, and that the time limits and other provisions of the bill were unnecessary, uncalled for and put a serious hindrance, even a menace, upon legitimate commerce in the food products of the country.

There was brought before the committee also a mass of scientific testimony of the first importance. This testimony was given by Dr. M. E. Pennington, in charge of the Food Research Laboratory of the United States Department of Agriculture, who has done a greater amount of research and experimental work on food products in cold storage than any other investigator in the United States, if not in the world; Dr. L. A. Rogers, in charge of the laboratory of the Dairy Division, Bureau of Animal Industry, of the United States Department of Agriculture; Dr. William J. Gies, Professor of Biological Chemistry, Columbia University, New York; and Dr. Herbert D. Pease, in charge of the bacteriological work of the Lederle Laboratories, New York. Each of these scientists is an acknowledged authority in his own field, and their conclusions are considered authoritative and final. All were in accord on the proposition that no facts exist that either warrant or justify a time limit of less than twelve months on perishable food products held in cold storage—which food products are the subject of the proposed restrictive legislation.

At the conclusion of the hearings before the Senate committee to sum up the case, the joint committee, through its counsel, filed an analysis of the whole testimony in the nature of a final argument on the bill. The whole proceedings were conducted in an able and intelligent manner, and the joint committee has expressed itself as well satisfied with the manner in which the question has been put up to the United States Senate. The bill was still in the hands of the Senate committee, and no report on it had been made when Congress adjourned. No further action, therefore, can take place before the next session, beginning in December. It is safe to predict, however, that the intelligent and successful effort made to bring the real facts in relation to the cold storage business pointedly before the Senate will bear good fruit. It is increasingly evident that our national lawmakers have been impressed with the importance of going slow in this matter and of getting at the exact facts in the case before enacting into law any hastily drawn legislation. The cold storage agitation and the consequent efforts to put proper information before Congress have had the effect of waking the legislators to the great importance of cold storage in the proper handling and preservation of the nation's food products. Cold storage warehousemen do not fear proper governmental regulation; they court the very fullest invesigation. They are rendering a valuable and important service in the handling and conservation of the food supply of the nation;

they are doing it well, and they know it. The sooner the people and the lawmakers find out the actual facts, the sooner will misguided agitation subside and danger of restrictive and harmful legislation disappear.

DISCUSSION.

Theodore O. Vilter.—I can say that, while I have followed up the conditions in the cold storage plant, Mr. Switzler has gone into the details very much more than I have. I think that his investigation is worthy of a great deal of consideration, on account of his having gone into it so thoroughly.

J. F. Nickerson.—Mr. Switzler has presented the case very fully. I would say this, however, that I do not think that we are through with this fight for reasonable legislation, by any means. I think that it is quite necessary for every one, and all bodies interested in this matter, to continue to take an interest in it, and co-operate in an effort to secure favorable legislation. I will say that at a meeting of the American Association of Food, Dairy and Drug officials, recently held in Duluth, a committee was appointed to investigate the subject and report at the meeting a year hence. I understand from the chairman of this committee, Mr. Barnard, who is the food commissioner from Indiana, that they propose to draft what they consider a model bill, with the idea that such a measure will be adopted by the various states. I think, therefore, in view of all this, that it is quite important that this particular committee be followed closely by those who are interested, in order to see that they investigate the subject fully, and, if possible, arrive at just conclusions.

There are other things in which the various associations should co-operate. It is undoubtedly a fact that it will be necessary to continue the fight in Washington in the regular session next December. The manufacturers' committee there will undoubtedly make some report, and possibly hearings may be given by the House committee, which also has one or two bills under consideration. Therefore, it behooves every one interested to keep an eye on this matter and especially to watch the national and state legislatures in order that we may, if possible, safeguard the cold storage interests.

Herbert Moore.—I quite agree with Mr. Nickerson. I have noticed, since this agitation on cold storage has been brought out, that it has a tendency to make the cold storage men sit up and take notice. Heretofore they have simply run the cold storage business as a business. I have claimed that the preservation of food com-

modities is a science. You must study your business all the way through if you want to make it a science. I also have urged that we all keep in close touch with the legislature. We are going to have some kind of legislation—there is no question about that—and what we want is something that will please the people and satisfy the cold storage men.

J. F. Nickerson.—I want to correct a possibly erroneous idea that may be created by Mr. Holzbaur's report on the Conservation Congress. The question of the preservation of foods under refrigeration received some consideration. The president of the American Association of Refrigeration, W. J. Rushton, of Birmingham, who was chairman of the delegation of that committee attending the congress, spoke on the floor in reference to this subject, and asked to have this special standing committee appointed to investigate foods. Professor Northrup, of Minnesota, gave an address upon that subject, and spoke very favorably on the refrigeration of perishable foods for conservation and preservation for the use of people.

The general impression our delegation received from that congress was that many of the public men, and the public generally, were awakening somewhat to the benefits that had been derived from the application of refrigeration to food conservation. I think we have made considerable gain this last year, and if we can continue to make as much progress in the years to come, I think we shall have the cold storage business on a sound basis, and where it will be more thoroughly appreciated. In the end this agitation and any legislation that we may have will be bound to benefit the cold storage business, because it will place it on a sound footing, a higher plane, and people will begin to appreciate what cold storage goods are. They will know that the best goods produced go into cold storage, and are kept in the best condition, in order to serve the times of the year this this class of goods cannot otherwise be obtained. I think we can congratulate ourselves that we have made considerable progress this last year.

George Berna.—I would like to ask Mr. Switzler one question: We have always read about this legislation on the matter of time; is it not legislation on sanitary conditions that we want? We have seen cold storage plants in which we would not want to have our food kept for an hour, and we have seen others where we would not care how long they were kept; we know that they would not spoil.

R. H. Switzler.—Our position on that is that no one should store anything in the wrong kind of a cold storage plant. You'll

not find anyone who will advise you to store anything in the wrong kind of a cold storage plant. He will further say to you that if you want to see the right kind of a plant he will be very glad to show it to you. That is what every man will say.

When you speak of conditions, the main thing is the condition of the foods that we store. That is the point that is made by the chemical experts. The matter of time in store is not of nearly so much consequence as the condition of the goods when they are stored. The goods must be in proper condition before they are stored to secure good results, and that is the point we are going to make. There must be inspection of the house, but it is more important to have inspection of the goods themselves before they are stored.

In New York City, in the last two or three weeks, there have been newspaper "scareheads" as to the horrible condition of the cold storage houses, describing the filthy rooms and telling the number of microbes per cubic centimeter.

J. F. Nickerson.—I would like to say just a word on that point, as none of our New York cold storage men are here to defend themselves. They have a peculiar condition in New York state in the matter of cold storage legislation. When the law was passed in Albany, there was created a fund of $40,000 to use for prosecutions, and Mr. Brennan, the gentleman who introduced the bill, has been retained by the Commissioner of Health in New York City, at so much per day, to assist him in seeing that the law is carried into effect. It follows at once that as long as this $40,000 lasts there will be a great deal of agitation on the subject of cold storage.

President Friedmann.—They will prosecute to the extent of the $40,000.

J. F. Nickerson.—They will prosecute as far as that at least.

Albert Johnson.—While traveling through New York, six weeks ago, I met one of the state inspectors who was visiting cold storage houses to recommend where they should make changes and clean up and whitewash this and cement that. They have inspectors already looking after the sanitary condition of the plants. One of the inspectors told me that he had struck only one or two plants which were very filthy.

President Friedmann.—Of course, it is a little foreign to the subject, but if you have political appointees as inspectors, you have a lot of fellows who have no idea of what the sanitary conditions should be.

I recall one case in North Carolina where an ice plant was condemned. It had been running for years and nobody said a word about it until there was typhoid fever in town, and they complained that everything was unsanitary at the ice plant. They put restrictions on that ice plant. For instance, every cover of the cans had to be washed every day with a solution of bichloride of mercury of a certain strength, and the top of the tank had to be mopped at another time of day with the same solution. They made a lot of conditions which, if really carried out, would have made it impossible to continue the plant. The plant would constantly be in an unfinished condition and they could not operate it; it would be impractical. After the physician in charge of the board of health began to investigate the real cause of the epidemic, which was the drinking water from wells, they suddenly forgot about the ice plant. They are going ahead now as they did before, all of which goes to show that when there is an epidemic, or some public scare, they adopt all kinds of radical measures for a few days, but after that it goes on in the same old way.

Roderick H. Tait.—I would like to ask what is meant by the inspection of goods. Is it proposed to open every package of goods that have been stored and passed upon them, to see whether they can be carried any longer?

R. H. Switzler.—No, we don't mean that. The cold storage man, in receiving the goods for storage, will, as a rule, make an inspection of the most perishable goods for his own benefit. For instance, every car of eggs we take into our plant is inspected by our inspector to see whether they are fit for storage. It is only occasionally that we receive goods that should not be stored. In that case we advise the owner that they should not be stored, and they are taken away. But that should be done by the government, if they want to regulate the business at all. It should be determined by statutory inspection whether the goods are in a proper condition. That can be done without examining every package. Take a carload of eggs, and the inspection is made by looking into ten cases out of four hundred. Take a carload of butter and inspect ten tubs, taking a tub here and there; a man will buy a car of butter on that inspection. Take a car of poultry, and they would inspect 10 or 15 per cent., taking packages here and there from the car. That is a satisfactory inspection. The government makes a satisfactory inspection of meat products, but they do it on meat, and nothing else. We are just now shipping out a car of meat, and there is an inspector there

all the time to look at the meat as it goes into the car. He occasionally samples a piece of the meat, and makes a satisfactory inspection. I asked him only yesterday the direct question, "How often do you find anything to condemn?" He said, "Very, very rarely," but occasionally he did. It depended upon the class of meat. Some meat showed a greater percentage to be condemned than others. You don't have to inspect every package; you can make a satisfactory inspection by examining a fair percentage. That is especially true of fruits. Some fruits should not be stored at all; some would have to be stored green. Take a Michigan pear. A Michigan pear has to be entirely green if you are going to put it in cold storage, otherwise inside of six weeks it would be gone. Most apples cannot be stored long. That is the case with all really perishable commodities. They can be inspected in a reasonable way without very much expense.

Roderick H. Tait.—It just struck me, if each individual package had to be examined every thirty days, to see whether it would carry another thirty days, it would be an impractical proposition.

R. H. Switzler.—It does not mean that, but when they are offered for storage. If they are in proper condition when they come in, the natural law of supply and demand will remove them at the right time.

I will cite an exaggerated case of what some people think. When we had this law before the legislature at Jefferson City, Missouri, I was talking with one of our unwilling Senators, and he said, "I understand these fishmen carry their fish ten or fifteen years." I said, "Mr. Senator, did you ever hear of a successful merchant in any line of business, whether he handled pig lead or pig iron, who kept his money wrapped up in his merchandise for ten or fifteen years? The interest on it would eat him up, whether he is a fishman, handling perishable products, or what-not; he does not carry them any longer than he has to to get his money back." It is absurd. They do not do it. The man with money in his goods can be depended upon to get rid of those goods in cold storage before the charges eat them up. You don't have to pass any law on that.

President Friedmann.—It occurs to me that any man running his cold storage business on rational lines will insist on proper inspection for his own benefit, and for the benefit of the business, irrespective of the law or its penalties. Any first-class business man will do that without laws, and the one who has to be compelled by the threat of penalties to do it will never make a success of business, anyway.

No. 91

THE HIGH SPEED AMMONIA COMPRESSOR.

By Theodore O. Vilter, Milwaukee, Wis.

(Member of the Society.)

The high speed compressor is a feasible proposition. Its possibilities depend, practically, entirely on the area of the suction valve and diameter of the compressor. Years ago I had an experience with a 11 x 30 inch compressor. I was called to a plant which was in trouble, to make recommendations. I found good insulation, plenty of direct expansion piping in the rooms, plenty of ammonia in the system and the compressor operating 75 r.p.m. I told the owner I must shut down to take out the compressor valves for examination, and also to ascertain the condition of the compressor.

I found that if I operated the machine at about 36 revolutions I would be able to cool all the rooms and give them the proper temperature without any trouble. The owner looked at me and thought I was ready for the insane asylum. A good many engineers had called at the plant before I came and they all advised him to speed up the compressor. I told him that I would stay with the machine for 24 hours and guarantee with a $500 check, which I was ready to deposit, that I would get an order to shut down because the cellars would be too cold by that time. He shook his head, but agreed. Inside of 14 hours with the compressor operating 35 r.p.m. the temperature was such that the brew-master ordered me to stop the machine. This proved that the valve area was entirely too small, and with the same size valves put into an 8 x 16 inch compressor, it would have carried all the rooms to the proper temperature when running 70 revolutions, provided the compressor was given the proper clearance. Therefore, it is the construction of the valves that will bring about the increased piston speed without injury to its efficiency.

Tests with an 8 x 16 inch compressor of a certain construction show that 100 r.p.m. is the limit. An increase in revolutions would bring about a decrease in efficiency. A compressor of a small diameter and operating with a shorter stroke at 275 r.p.m. showed

still an increase in efficiency, and there was no trouble in any part or parts of the compressor, but the suction valve was nearly the diameter of the plunger. That would show that there is no limit to the handling of the gas with proper suction supply and proper valve area.

In practice, however, I am personally against operating refrigerating machines at a high rate of speed just as I am against operating a steam engine at a high rate of speed, for the simple reason that the wear and tear is very much greater; and where a slow-operating compressor or engine will run for a great many years with but very little repair, a high-speed compressor or engine will require a great deal of repair. This is a much more important item in an ammonia compressor, which is to operate 24 hours a day, 7 days a week, and 31 days a month, and, in tropical climates, 12 months a year. The owner of such a plant cannot afford to shut down every little while for repairs. Consequently, my argument is that the slower speed compressor is the proper thing for all-around conditions. There is no other saving than the first installation in buying a few pounds less iron. The workmanship must be a great deal better on the high-speed compressor. What I mean by a slow-speed machine is, for example, one of from 50 to 100 tons refrigerating capacity, working at from 70 to 90 r.p.m.

The high-speed compressor would require a larger bore in proportion to the stroke, so as to get more surface in which to insert the proper valve area, because, in large compressor cosntruction, it is impossible to make valves the full diameter of the compressor, and therefore a number of smaller valves will be used. In order to get the increased area the diameter must be increased and the stroke shortened for a certain capacity, and that, of course, increases the clearance, which is also detrimental to compressor construction.

DISCUSSION.

V. R. H. Greene.—We have a 20-ton machine at 70 r.p.m., direct connected to one of our oil engines with which we are experimenting. We have been running it now for about eight months, 225 r.p.m., and while, of course, we are not getting the efficiency out of the machine that we would get if we were running it slower, we are not altogether looking for that, for since it is direct connected to an oil engine, it is an economical unit from the standpoint of number of tons of refrigeration for the amount of power expended, and that

was our main idea. We do not find such an enormous wear and tear on our equipment as one might expect, probably due to the fact that the inertia of the fly-wheel at that speed is so great that it tends to relieve the strain. You take a large machine, for example, and run it down to 25 r.p.m., so that you can see the crank stop every time it goes over the center—and that, of course, is the most wearing condition you can possibly meet. But if you run at a reasonable speed, that energy is saved. We are getting some rather remarkable results at a speed of 225 r.p.m. It is a 20-ton machine, and does very good work right along. We are getting 25 tons out of it and sometimes as high as 30 tons.

Louis Block.—What is the size of the compressor?

V. R. H. Greene.—9 by 18 inches, double acting, standard horizontal.

President Friedmann.—It is specially constructed?

V. R. H. Greene.—It is a standard machine except for the valves, which are of German style. The valve consists of a flat disc with a steel spring plate on the outside of it, which tends to buckle away from the center and give a valve area around the outside. I believe some tests have been made in England, and I presume Germany, too, on this subject of valve design for high speed.

J. S. Louis.—Mr. Greene, how much increased capacity do you get out of it?

V. R. H. Greene.—Why, we get about 50 per cent. more work. The object, of course, is ultimately to increase the efficiency. We are experimenting with it now, and the whole question lies in the construction of the suction valve so that the cylinder fills. Now it does not fill properly.

J. S. Louis.—Running at three times the normal speed?

V. R. H. Greene.—Yes.

President Friedmann.—I think, Mr. Louis, that the main point Mr. Greene makes is that his machine is a standard machine hooked up for experimental work. I understand he does not claim it is a machine that is on the market. And the other gentlemen here have said that in order to make a high speed compressor a success it must be constructed specifically for high speed..

V. R. H. Greene.—The one we have been testing is not efficient at high speed and would not be put on the market as such, but it can be improved. It makes an ideal combination to run with a gas engine.

Louis Block.—Mr. Vilter, you don't mean to contend that the

wear and tear per revolution in the high speed compressor is greater than in the slow speed compressor?

Theodore Vilter.—No.

Louis Block.—Then it does not make any difference?

Theodore Vilter.—Not directly.

Louis Block.—If you can run a slow-speed compressor twenty years, you can only run a compressor at 180 revolutions ten years; is that your argument?

Albert Ruemmeli.—Yes, that is about the argument, taking all the bearings into consideration, if I may be permitted to answer that question.

Louis Block.—Now, you also quasi-condemn the high speed steam engine?

Albert Ruemmeli.—Yes, I do.

Louis Block.—But you know that the high speed steam engine is more economical than the slow speed steam engine?

Albert Ruemmeli.—When it comes to a certain limit, yes.

Louis Block.—You know that the latest European practice is to run steam engines from four to five hundred revolutions a minute?

Albert Ruemmeli.—I know it.

Louis Block.—Well, do you think, with their economical minds over there, they would build such engines if they were afraid they would break down in a very short time? Don't you think they may be built in such a manner that they will stand up just as well as the slow speed engine?

Albert Ruemmeli.—I am an old-timer, but that is my idea about it, not to operate at too high speed. There is always a difference of opinion on that proposition; it will always remain so. In answer to Mr. Block's statement, I wish to say that Mr. Vilter probably had a Corliss engine in mind, which we use here generally. We could not run Corliss engines at that speed. If you run Corliss engines of 100 or 200 horse power around 100 to 120 r.p.m. it will not last very long. If they have engines in Europe that run at the high speeds, as Mr. Block states, they must be entirely different in construction from those we generall use here. Even the Sulzer engine cannot run at that speed. In a 100-horse power or 150-horse power engine, you cannot possibly run more than about 120 to 150 revolutions. Now, Mr. Block must have some different engine in mind.

Louis Block.—Of course I did not speak of Corliss engines. I spoke of engines, and Mr. Ruemmeli is still mistaken. He evidently

does not know what the Hewes & Phillips Iron Works, Newark, N. J., are doing. They are building Corliss engines with ordinary releasing gear cut-off, and they run them from 150 to 200 r.p.m. I know of two such engines which have been run now for three years, 300-horse power and 250-horse power, and they do not show the slightest bit of wear and tear, no more than any other engine which runs 100 r.p.m. I have seen a model in their shop which ran 218.

President Friedmann.—As I understand it, Mr. Block, the trouble would be with the ordinary vacuum dash-pot when it came to speeds above 125, where it would not work satisfactorily. I understand they have made a change. Frank Phillips has a patent on a new kind of gear for his engines.

Louis Block.—It is the old vacuum dash-pot, and it has a double ported valve.

President Friedmann.—The difference would be in the double port, which allows a shorter motion. There is no question but that the tendency is for high speed engines. You can scarcely find any very slow speed dynamos nowadays, except for some particular, special purpose, and the economy naturally must be greater in high speed, otherwise it would be very quickly detected, since there is no machine in the world easier to test than an electrical unit. I think Mr. Louis, who builds electric dynamos driven by high speed engines, would be able to tell us something about the difference in economy between high and low speed.

J. S. Louis.—I am not as well versed in the electrical end of our business as I should be. My observation is that there are a great many Corliss engines, electrically driven units, still being purchased to run anywhere from 140 to 170 revolutions, and a great many of our generators are used on Corliss engines. Invariably, where the customer is looking for economy of operation and endurance of engines, they are buying a Corliss engine outfit. Where we find a customer who wants to get something cheap, he buys a high speed 4-valve engine, but the biggest customers, outside of the electric companies themselves, are buying Corliss engines, and I believe that Mr. Vilter will agree with me there.

Thomas Shipley.— In regard to the speed of compressors, the tendency of the times is toward high speed, very high speed, and the only limitation I can see in the speed of a compressor is the possibility of designing suction valves so that the compressor will fill up at each stroke. It is a well known fact that in high speed engines the valves must be large and quick acting so as to give steam free entrance to

the cylinder. It is the same with the compressor. The suction valves and connections must be made large and the passages free if they are to be run at a high speed.

At York, during the tests we made, we ran the compressors at as high a speed as our Corliss engine would drive them, which was about 125 revolutions, and we found, with the single acting machine, that the efficiency increased with the speed. The double acting machine began to lose efficiency at the high speeds because the ammonia could not get into the cylinder fast enough. The valves were too small and not so well balanced.

I have reports from compressors in Europe, said to be running 700 revolutions. We have machines on our testing blocks at York which we have run at 250 revolutions and we hope to reach 500 revolutions. Some of our best Corliss engine builders are listing their standard engines at 200 revolutions, and they will take contracts to build engines to run at a much higher speed.

The suction valve is the key to the speed question, and is the rule of the day, hence if we want to stay in the procession we must speed up our compressors. One of the problems of the day is to produce a compressor which can be direct-connected to a gas engine, which runs at a reasonably high speed. If any of us decide that we will not speed up our compressors, we will soon find that some other fellow will. European builders are using a flat disc, or spring, suction valve on their high speed compressors.

Louis Block.—A little more than seven years ago I designed a compressor which was 12 inches in diameter by 14 inches stroke, and that compressor ran in the De LaVergne shop for about four years uninterruptedly at 170 r.p.m., compressing air to about 80 pounds pressure, which is about the same condition as a refrigerating machine would work under. It was practically two single acting compressors with the suction ends turned together. The gas entered in the center between the two pistons, which were on one rod. Each piston had five 2½-inch balanced suction valves, and the gas entered through a belt around the center of the compressor and finally through a number of openings into the compressor, so that the entire opening was very large, allowing the pressure between the pistons to be exactly what it was in the suction pipe.

One end I rigged with a 6-inch discharge valve, because a blast furnace superintendent of great experience had told me that it was not possible to run a blowing engine with 6-inch valves faster than 40 revolutions a minute, or it would bang itself all to pieces. I told

him that I thought I would be able to show him that it could be run at a higher speed, and for that reason I put on the 6-inch valve. At the other end we had five 2½-inch discharge valves. That compressor did good work; it showed good diagrams, which were taken about every six months for four years, to my knowledge, when it was disconnected. I don't know whether or not it was because that part of the De LaVergne shop in which it was located was cut off to accommodate the railroad, but the compressor was moved or has disappeared altogether. That was seven or eight years ago, Mr. Shipley, and it ran at 170 revolutions.

President Friedmann.—Mr. Ruemmeli, will you let us have your opinion on the subject of high speed compressors? You have been building machines for a good many years.

Albert Ruemmeli.—I agree perfectly with our friend Mr. Vilter, to run the size machine he mentioned at the speed he said, for the reasons he gives.

President Friedmann.—I think Mr. Shipley's remarks cover that point—that the tendency for high speed is on account of what Mr. Greene just stated, the use of the gas engine. Unfortunately, not having these compressors in existence to-day, we have to use dynamos and then motors, with the consequent losses.

Peter Neff.—About twelve years ago, my attention was called to the matter of high speed engines, and talking with engine builders I found there seemed to be a tendency toward high speed. That has been talked over here, and you have heard what the engine builder has done. He has had to make some little modifications in his engine from the old time Corliss engine until he has got up toward the 200 r.p.m. mark and working satisfactorily. Naturally, the thought came then that the high speed compressor would have to come. With that in mind I looked into the matter of high speed compressors very carefully, and ran across a great many things that were interesting. I found that there had been a good many improvements on compressors brought out, but not adopted. I talked the matter over very thoroughly with Mr. Block. He kindly showed me the drawings of the machine that he has mentioned here. My attention was called to L. Sterne & Co.'s compressor, which I think has somewhat the same kind of valves that Mr. Greene has been speaking of. There were also many others in this country and abroad.

The first thing that suggested itself was the attempt to get the gas into the cylinders; in other words, to fill. Manifestly the com-

mon type of compressor cannot do that. There is a speed limit fixed, and it is fixed when the builder makes it. As Mr. Vilter has said, the increase in speed does not help you any; in fact, it does you harm in ultimate results. Mr. Shipley has been talking about this same matter, running his vertical machines at considerably higher speeds than the ordinary operating engineer was accustomed to run, and he seemed to get very good results.

There is a reason for that. He has explained it here, owing to the single acting compressor and the large valve area he is able to get the gas into his compressors. Now, the problems connected with that are various; the suction and discharge have got to be taken into very careful consideration. And I will say for your benefit that we have been through quite an experience in that line, and we are able to fill the compressors satisfactorily at any speed under which we have been able to operate them. There is really just as much trouble with the discharge valve as there is with the suction. That has got to be taken care of. In other words, it is just a mere question of problems confronting you from start to finish. But there is not a maker of ice machines here to-day, if he is going to keep up with the procession, but must meet these problems and work them out. We are, I think, rapidly approaching that time.

Now we have the high speed steam engines, and we have to provide for the oil engine and gas engine and other types of internal compression engines which are coming into the market—and they are coming fast. Take our Western country, all underlaid with lignites that will produce a horse power through a gas producer for about what you get out of your hard coal under boilers in the East—all this is ultimately going to become available, and there are going to be endless opportunities for operating plants with these high speed engines, and the compressor has got to meet them. Just what the results will be I am not prepared to say. I heard Mr. Shipley say that he is figuring on 500 to 700 revolutions. I am not surprised. I had not set any limit, but as we go along we will find our limits for different types of construction.

There are other questions besides that of valve area that will have to be taken into consideration in construction. We have found that the ordinary rules of figuring strains and stresses are not adapted for excessive high speeds under the hard conditions that those machines are asked to meet at times. Take one machine running at a high rate of speed and you have no troubles at all. Take another, and you will find local conditions such as to cause difficulty. These

things must be met, and you will have to get formulas for the parts to meet the worst conditions you are going to encounter.

Just bear in mind, though, that you must fill your cylinder for this high speed, and keep the gas as cold as you can, and you must get it out. It not only requires a larger area in the valve ports, but the present plants, with their ordinary suction and discharge lines, are not large enough in many cases for high speed compressors.

We have a machine in operation in a cold storage plant in this city direct connected to a producer gas engine. That machine is operating, and any of you can go there and look at it. It is doing the work.

The Secretary.—How fast does it go?

Peter Neff.—It goes 128 revolutions at its normal speed. That machine introduces a little different problem, for the reason that we have to have two gas compressors on it to meet Mr. Tait's necessities, so we have the two compressors operating under different conditions. Those two compressors give a balanced load on the engine.

President Friedmann.—What type of gas engine is driving that compressor?

Roderick H. Tait.—It is an Allis-Chalmers, two cylinder, horizontal, 21 by 30, double acting.

Victor H. Becker.—Last Friday, in going over some old German publications, I came across a translation of an article written by Richard Stetefeld, which I think was published in *Ice and Refrigeration* about 1904 or 1905. It was on the subject of flat disc ammonia compressor valves, and in a letter, which it just happens I have in my pocket, he speaks about this subject of speeding up compressors, and of the effect of improvement in valves to that end.

The English is not very good, it being almost a literal translation. He says:

"Which expert does not know from his own experience that these pleasing properties of our heretofore known valves, such as friction rings or tight bushings, and the bad effects of the inevitably large weights of the valve; therefore, it was always endeavored to construct valves approaching the weightless ideal valve as close as possible. The best solution of this problem that presents itself at this time is without doubt the flat disc valve." (He calls it a "trap" or "leaf" valve.)

And then he goes on and describes it. It is familiar to you, therefore it is not necessary to read it. He further says:

"As it is further possible to insert without difficulty the traps in such a way that alterations in the course of the gas, or the formation of whirls will occur but in a slight degree, and as a rapid and complete opening of the traps

will be effected by the low weight of the trap, it is evident that these trap valves are destined to diminish perceptibly the depression through suction and the over-pressure during compression. Besides this indisputable advantage of the trap valve, there is still another one as the result of its low weight. A body of small mass can endure a considerably greater acceleration of the mass without the danger of breaking, as is proved by the law of physics. This means a higher number of revolutions of the compressor compared with construction used heretofore. Such a higher number of revolutions again permits smaller dimensions and an increase in the capacity of a given already constructed compressor, and therefore a smaller initial cost, not only for the compressor, but also for the engine, in case the compressor is directly connected with the latter."

I merely call your attention to this because I happen to have it in my pocket. I brought it with me to study on the train, and it just happens to be apropos of this discussion.

Louis Block.—I might say that the Mullan air pump is now equipped with these Gutermuth valves, and they are running readily 125 to 150 revolutions. A good air pump must have a promptly and tightly closing valve. If it is possible to do that in an air pump, why should it not be possible to do it with the compressor?

President Friedmann.—Then we are agreed that the use of the Gutermuth clack valve, or that general construction, would be recommended for this purpose?

Thomas Shipley.—The Curtis people use a disc valve in their air compressors, which are made right here in St. Louis.

No. 92

THE PROTECTION OF REFRIGERATING APPARATUS AGAINST CORROSION.

By Morgan B. Smith, Syracuse, N. Y.

(Associate Member of the Society.)

The protection of refrigerating apparatus against corrosion involves three main heads—namely, the metallic apparatus, the brine solution, and the relation of the refrigerating apparatus proper to the other apparatus in the vicinity, especially with regard to the generation of electric current. With regard to the refrigerating apparatus, I shall consider the following factors; first, the nature of the metals used, with regard to their ability alone to resist corrosion and their tendency when in combination to set up galvanic action and induce corrosion; second, the design of apparatus and general workmanship shown in assembling the varied elements which go to form the finished plant.

The nature of the metals used and their combination is worthy of very close study, as both practice and experimentation have proved. For example, if we place two electrically dissimilar metals, such as brass and iron, in a brine solution, an electric current is at once set up, such a current passing from the iron to the brass through the brine solution. The action of this current is such that the iron gradually passes into solution, and subsequently is oxidized to form the familiar oxide called rust. The solution of the iron in such a case may take years. On the other hand, it may take a much shorter time, for the rapidity with which such a reaction takes place varies directly with the magnitude of the current set up. This is equally true of the combination of any electrically dissimilar metals, only varying with the relative degree of dissimilarity in the metals used, and for this reason it is perfectly obvious that, in so far as possible, but one metal should be used in refrigerating plants. Not only should but one metal be used, as far as possible, but that metal should be of the greatest possible purity, for impurities in metal act in much the same manner as do two dissimilar metals mechanically combined. This is especially true of cast iron, which is frequently destroyed by

the numerous local currents set up between the iron and its impurities, leaving the casting in a characteristic graphitic condition. It is well at this time to consider the widely used combination of two electrically dissimilar metals in galvanized iron.

Zinc resists corrosion in a brine solution if no electrically dissimilar metal be present. If, however, iron is present, the zinc will go into solution, thereby protecting the iron as long as zinc is present in sufficient amount. Therefore, it is plain that galvanized iron should never be used excepting that of the very best quality, in which no iron whatever is exposed. When galvanized iron does show iron exposed at pin holes, or along seams where bending has cracked the zinc film, it is next to worthless in brine solutions, for, sooner or later, all the zinc will be stripped off, leaving the iron bare. As there is evidence that the highest grade of iron is not used in the manufacture of galvanized iron, it is obvious that the iron itself will be more liable to corrosion than would a plain iron apparatus of a high grade of purity. It is doubtful, therefore, if galvanized iron should ever be used, since it seems almost impossible to construct apparatus of this material so that only zinc will be exposed to the brine solution. Many alloys resist corrosion to a marked degree, especially the bronzes. Alloyed copper in iron tends to retard corrosion, whereas unalloyed copper in iron greatly hastens the process.* From the foregoing facts it is very evident that but one homogeneous metal should be used as far as is practical in the construction of apparatus.

The design of apparatus, especially of fittings and piping, is very important, and is generally wholly neglected. When a piece of metal is strained an electrical difference of potential is at once set up between the strained and the unstrained portions. The strained portion is always positive toward the unstrained portion, and it is the strained portion which is attacked and eventually destroyed. This state of affairs is exemplified in the case of threaded pipe ends, engaging fittings, the pipe ends being strained, while the remainder of the pipe is unstrained. There can be no doubt whatever that this state of strain in pipe ends is largely responsible for the failure of piping at the threaded portions. This is almost equally true of fittings, which, however, generally have so much more metal remaining after the threads are cut that the strain caused in them when making up joints cannot be as great as it is in piping where comparatively little metal is left after threading. There are a number of instances where pipe trouble has been eliminated by the use of piping and fit-

* *Engineering News*, Aug. 3, 1911, p. 165.

tings of extra weight, so that after the threads are cut sufficient metal is left to allow the making up of joints without undue strain.

Experiments have proved that torsional strain is far worse than tensile strain, although in brine lines it is often very evident that both types of strain are inflicted at the time of erection. Experiments carried out on steel which had been given torsional strain showed, for a wrought iron forged shaft, 16 milli-volts difference of potential between strained and unstrained portions; for soft steel in the same test, 3 milli-volt; for chromium steel, 1 milli-volt, etc., all sufficiently high to greatly hasten corrosion.†

A heavy brine at high pressure exerts a severe cutting effect at turns under the impulse of the brine pump. It is well, therefore, to use bends of as great radii as possible, wherever practical, as the average life of long-turn bends far exceeds that of short-turn bends under the same conditions. Air is one of the great accelerators of corrosion, and it is very essential to see that there are no air pockets in the apparatus, especially in the piping. All high parts in the piping and each piece of apparatus, as far as is practicable, should be provided with suitable vents, so that any trapped air can be withdrawn from time to time. If an air pocket does exist at a point for some time, corrosion soon makes itself manifest, and, if allowed to go on, will eventually cause failure at that point.

THE EFFECT OF BRINE.

We may now consider the brine solution to be used. Since the brine is made up by dissolving certain chlorides in water, it is very evident that the nature of that water is sure to affect the resulting brine solution. Water containing acid of any description should never be used, since the resulting brine will also be acid. An acid brine is far more corrosive than a neutral or an alkaline brine.

As a matter of fact, all brine solutions should be tested from time to time for acidity, and, if found to be acid, they should at once be neutralized with some alkali, such as lime or caustic soda. Sufficient alkali should be added to make the brine distinctly alkaline towards a suitable indicator. The best indicator for this purpose is phenol-phthalein. This is made up by dissolving phenol-phthalein in alcohol—about ½ ounce in 2 quarts—and adding to the solution 2 quarts of distilled water. Another good indicator which may be

† *Bulletin of the University of Wisconsin*, Number 2, Engineering Series, Volume 11, No. 8, July, 1900.

used in conjunction with phenol-phthalein is methyl-orange, which is made up about 1/10 ounce per gallon.

If the brine is alkaline, as it should be, a pink color results when a few drops of phenol-phthalein are added to a small sample of the brine. If the brine is acid or neutral, no pink color results. If the brine is alkaline, as it should be, a yellow color results when methyl-orange is added to a small sample of the brine. If the brine is acid, a red color results. It is well to use both indicators, as one checks the other. When making up brine it is well to avoid saturating the brine with air, for brine saturated with air is far more corrosive than brine carrying only a minimum amount of air in solution. Brine should never be agitated with an air-blast, nor should it be allowed to fall through the air into tanks, as is often the case with return-brine. Return-brine is often very nearly saturated with air in just this manner. As for the strength of the brine and the temperature, it is certain that the greater the concentration and the lower the temperature the less likely is the brine to assist corrosion.

The selection of the chloride to use in making up the brine solution is no longer a serious problem, since practice and laboratory experimentation have proven the truth of the assertion that the most economical and the least corrosive chloride is that calcium chloride which contains as small an amount of magnesium chloride and of sodium chloride as possible and the least practical amount of water. There is no longer any doubt that magnesium chloride and sodium chloride in calcium chloride brine materially increase the corrosiveness of the resulting brine, compared with a brine containing practically no chloride other than calcium chloride. This is especially true if the brine containing magnesium chloride becomes acid through the unstable nature of magnesium chloride. I have been asked whether ammonia present in brine would increase the corrosiveness of the brine. Experiments of long duration, in which the ammonia content of the calcium chloride brine in question was maintained at a constant value, show that ammonia tends to retard corrosion, rather than hastens it, when present in sufficient amount.

THE EFFECT OF ELECTRIC CURRENTS.

We may now consider the refrigerating apparatus in its relation to the generation of electric current and its distribution. The corrosion which we have considered so far has to do with the inherent relation between unlike metals and an electrolyte, which, in

this case, is the brine solution. Such corrosion may be greatly hastened by the action of stray electric currents, which find a way into the refrigerating apparatus from which they pass to some neighboring metallic circuit or directly to ground. If the refrigerating apparatus, in whole or in part, is positive in electrical potential towards ground, we may be sure that some stray electric current is finding its way into the apparatus, and that corrosion, local or general, is being hastened along in proportion to the magnitude of that stray current. Not many engineers realize the truth of this assertion—namely, that it is the small currents which cause the most trouble, since they are not looked for in testing, and so are able to go on and on in their destructive action. Wood says, in his book on Rustless Coatings, that "a difference of potential of 1/1000 of a volt is all that is required to start ferric corrosion two miles from the dynamo."

Therefore, in testing out refrigerating plants, it is absolutely essential to make the tests sufficiently delicate to detect currents of as low a potential as 0.5 milli-volt or lower. Tests made of many plants show that potentials as low as 0.4 milli-volt have set up severe local action which finally resulted in the failure of apparatus at that point. Some of this trouble comes from faulty insulation; some from very poor installation of metallic conduits, which are neither properly insulated from their supports nor properly grounded, and some from poor wiring, since very often wiring is found in actual contact with the brine lines.

Any or all of the above conditions cannot do otherwise than assist corrosion. If current finds its way into an improperly installed conduit, that current is bound to find a path to ground. This path is very certain to be a metallic one, and is very likely to be the brine line of the refrigerating apparatus. It is a wise precaution, therefore, to see that current apparatus of all sorts is properly installed, so that it will not be a continual menace to the refrigerating plant.

I have endeavored to place before you, as briefly as possible, the results of five years' observation of, and testing at, refrigerating plants of almost every description, from the small 50-ton plant to the great plants supplying refrigeration in our market centers, in the hope that this information may be of value to the refrigerating engineers of America and to those operating our plants, that they may be better able to design and to operate our refrigerating apparatus.

DISCUSSION.

W. H. Bower.—We have not had to deal with calcium chloride brine solutions. Our brine has been sodium chloride and used in an entirely different way—a saturated solution of sodium chloride in water, used in electrolytic cells, for making chlorine and caustic soda. And we find that we can store brine in steel tanks if they have set up in them a slight current opposite to the corrosion current, and we have adopted that means for storing our brine. It is a perfectly feasible thing, and it protects your tanks perfectly.

Mr. Smith's paper is certain, I think, to lead to great results not only in refrigerating, but in steam piping. In the use of steam coils in boiling solutions, we have found that the coils are attacked in certain cases where there is absolutely no reason for the quality of the liquid to affect it—for instance, caustic soda, which has no action on iron or steel; but there is a very distinct corrosion of that pipe on the inside of the coil. The coil there is under strain, and we find the pipe trying to straighten itself out under the pressure of the steam exactly like the little tube in a steam gauge, and the current is set up there. I have not the exact measurements of the current that is set up, but we know there is corrosion from that cause, and for that reason we have given up using bent coils. We would rather take our chances with steel or iron pipe, put together with malleable iron fittings, than to use bent pipe.

President Friedmann.—Mr. Bower corroborates what Mr. Smith said as to the increased tendency of pipes under pressure to corrode.

Albert Ruemmeli.—In regard to the use of calcium brine for ice manufacturing tanks, I wish to state this: In most cases I have always used salt, except where I had to furnish very low temperatures, when I used calcium brine. I would like to know from Mr. Smith what trouble an engineer may have when he has leaks in his brine tanks. For instance, if you have a brine tank filled with ice cans, in calcium brine, and you get a big leak, what would become of your brine?

The Secretary.—An ammonia leak?

Albert Ruemmeli.—Yes, an ammonia leak.

M. B. Smith.—I should say that, so far as the presence of the ammonia in the brine is concerned, it would not increase the corrosion; but it would cut down, I believe, quite materially the actual

effectiveness of the brine, simply due to the fact that more or less ammonia may combine with the calcium to form ammonia chloride.

Albert Ruemmeli.—What will become of the calcium contained in your brine solution if you have a bad brine leak? I want to find out whether or not the calcium will separate from the water and form a deposit?

M. B. Smith.—You mean by precipitating?

Albert Ruemmeli.—Yes.

M. B. Smith.—No, I do not believe so; I cannot see any reason why it should.

Albert Ruemmeli.—I had in Kansas City an experience using calcium brine. The foundation of the tank settled, and, since the connections from the coils to the suction header were fastened to the wall, the lower part of the joints opened in the tank and a large portion of the ammonia escaped into the brine. The result was that inside of a week or so the calcium had entirely separated from the water, and we had from a foot to fifteen inches of calcium in the bottom of the tank. We had to take out the coils and the cans so we could shovel that stuff out of the tank. And it was just like shoveling lead, it was so tough.

The Secretary.—Like hot asphalt?

Albert Ruemmeli.—Yes, something like that. Did you ever have any experience in that line?

M. B. Smith.—Not to any such extent as that. I did have an experience in a plant on Staten Island, and also in a plant in Philadelphia, where they have had a similar experience, but on a much smaller scale. In that case the calcium did separate out with the formation of a double chloride of zinc and calcium. But, as I say, I did not at that time attribute it to ammonia.

Albert Ruemmeli.—It is the ammonia?

M. B. Smith.—It may be possible. I can say that I have carried on experiments with ammonia present in such proportions as you might find from small leaks.

Albert Ruemmeli.—Of course, there they did not have small leaks, but big ones. There were a dozen or so connections leading to the suction headers. I considered it a very dangerous proposition to use calcium brine where you are not absolutely sure that you will not have any brine leaks.

M. B. Smith.—On the other hand, if you go into the chemistry of it, you will find that the double chloride of sodium and zinc is, if

anything, less soluble than the double chloride of either megnesium and zinc or calcium and zinc.

Albert Ruemmeli.—You would not have that trouble if you used sodium chloride.

M. B. Smith.—I think you would. I cannot state positively, because I have not had any experience in just that case; but I do know, so far as the chemistry of it is concerned, you would be just as likely to have it with sodium chloride as with either calcium or magnesium.

President Friedmann.—From your paper, there would seem to be no chemical reason why there should be a precipitation at all.

M. B. Smith.—Unless the ammonia is present in excess.

President Friedmann.—In this case it was there in excess. Would any impurities in the calcium chloride account for it?

M. B. Smith.—That depends entirely on the chloride used in making up the brine.

President Friedmann.—This is distinctly a case where the ammonia was there in excess.

M. B. Smith.—Yes; the experiments I have carried out were where the ammonia was not in excess, but the calcium was undoubtedly in excess, so that the two conditions are not parallel. I cannot state just what would happen. I should be very glad to take that up and see what we can find. It would be worth while.

President Friedmann.—What Mr. Ruemmeli wishes to know is whether it is advisable not to use calcium chloride at all, but to use sodium chloride? You say your chemical reasons tell you it makes no difference at all?

M. B. Smith.—That is true, so far as the theory of it is concerned. I am willing to admit that theory and practice do not always go together. That is why, instead of sticking in the laboratory and conducting these experiments under laboratory conditions, we have gone out into the actual field and visited many hundreds of plants in that connection. In this trip alone, I have been in some 60 or 70 different plants; and while we are still more or less in the dark, we are looking for facts. This experience of Mr. Ruemmeli's is new to me, and I shall be glad to follow it up in laboratory experimentation, and I would be more than pleased if I could see a practical case of that sort.

President Friedmann.—We would be pleased to hear from you further on that subject at the next meeting. You cannot blame Mr. Ruemmeli for not wanting to furnish material which is considerably

more expensive than another one, and which, at the same time, he believes to be really inferior and more dangerous in case of a leak.

M. B. Smith.—Yes, so far as I can see, except for a case of low temperature, as in a fish freezing plant. I have one case in mind, in Jersey City, where they carry brine 27 degrees below zero; that is pretty low, and, of course, calcium and magnesium chlorides are absolutely essential, in a case like that, for you cannot get extremely low temperatures with sodium chloride. For any temperature above zero chloride of sodium should work well.

I will say this, however, with regard to sodium chloride from the viewpoint of corrosion, that all of our experience has shown that both magnesium chloride and sodium chloride are, in the long run, more corrosive than calcium. That, of course, is eliminating all conditions which are in themselves conducive to corrosion, such as the presence of air, stray electric currents, combination of dissimilar metals, and so forth. We had a case not long ago, which I had occasion to investigate, where we had a fifty horsepower motor direct connected to a centrifugal pump. In fact, the motor armature and the cast-iron pump rotor were mounted on a common shaft. All the moving parts inside the pump were of brass, and at the top of that pump was a brass flange. Just why they put a brass flange on top of a cast-iron pump I don't know, but it was there, and the result was that the pump was badly corroded all around where it came in contact with the brass flange. The brass flange engaged a wrought iron vertical pipe, and that pipe was also eaten out. In fact, it seemed impossible to keep either the pipe or pump in condition and keep it from leaking.

We made an investigation and found a difference of potential of about 20 milli-volts—I don't recall the exact figure—between that pump and a good ground, which we established by burying a copper plate. This was about three years ago. We corrected that by tracing out the point where the current was getting into that system. Part of it came from the motor itself. There was current also coming from an annunciator circuit, one of the wires of the annunciator circuit coming in contact with the brine pipe, so that the current was undoubtedly getting into the system at that point.

President Friedmann.—I can corroborate that. I had a similar experience over in New York.

M. B. Smith.—Personally, I believe that the use of valves having iron bodies with brass parts is a bad practice. A valve is an expensive piece of apparatus to replace when it does go, especially in

the larger sizes. Therefore, I believe that it is better to go to the expense of putting in an all-brass valve. Of course, you have not eliminated the trouble in your system. If you have iron in contact with brass, the iron is sure to go eventually, anyway; but by using a brass valve you can connect up either side with either a short nipple or a short flange, so that when the iron does go you have only to replace that little short iron connection rather than buy a whole valve.

Walter S. Ashton.—I have a case in mind where we replaced brine in a tank. Apparently, things went all right for a while, and then a strong odor of iodoform developed to such an extent that it seemed dangerous to continue. We took it up with the chloride manufacturers, and they advised us to filter through animal charcoal. We did that and removed the odor, but in time that odor developed again. Can Mr. Smith account for that odor in calcium chloride?

M. B. Smith.—Are you sure it was iodoform or bromine?

Walter S. Ashton.—It smelled like a hospital.

M. B. Smith.—Bromine is a very common constituent of many chlorides on the market—those chlorides which result from the evaporation of natural brines. The bromine ought to be removed; it is a mighty valuable product. Bromine may give off an odor similar to iodoform.

Walter S. Ashton.—How do you account for the animal charcoal correcting it and then its appearing again?

M. B. Smith.—Animal charcoal has the property of taking out, to a large extent, odors of that character, simply by absorption.

President Friedmann.—After the charcoal is saturated it cannot do any more work.

M. B. Smith.—Perhaps that last statement is misleading; by odors I mean gases. It is a very common way of absorbing gases, due to the fact that charcoal, being of a spongy nature, has such an enormous surface.

W. H. Bower.—Regarding the question about the precipitation of the calcium from the calcium chloride solution. It would be impossible to make a precipitation with ammonia, because, as Mr. Smith knows, in our qualitative analysis for testing solutions we throw down our alumina and iron with ammonia, and ammonia chloride must be present there to prevent precipitation of the calcium as hydrate, and the reaction would be with the ammonia and calcium chloride, like this:

$$2\,NH_4(OH) + CaCl_2 = Ca(OH)_2 + 2\,NH_4Cl$$

M. B. Smith.—The only way I can see that it would be possible for the calcium to precipitate would be as a double compound of zinc and calcium. With ammonia present in small amounts—that is, with the calcium present in excess—there is absolutely no precipitation. But, as I said before, where the ammonia is present in excess, I don't know what would happen.

Albert Ruemmeli.—We first found the ammonia leaks, then we found the brine was weakening all the time. It started to freeze on top, and the calcium afterwards collected on the bottom of the tank to about 15 or 18 inches in depth, and we had to take out the entire charge of brine and shovel that stuff out, like a stiff mud.

Roderick H. Tait.—Is there any suggestion as to how we are going to protect our brine systems in large warehouses where we are told half a milli-volt will set up destructive action in the pipe, and where we are also told we will find half a dozen at every screw and joint? We have those strains all over the system. Suppose we free our system entirely from outside currents, we are just as bad off.

M. B. Smith.—The way we got around that in the case of the Frick Building in Pittsburg was by testing from the very lowest story—which, I think, is three or four stories below ground—clear to the top of the building, 22 stories. We put in a fairly heavy copper lead from top to bottom and fastened it to the well casing of the elevators, which we found to be a better ground than even the city water mains. We then connected the iron piping in at frequent intervals wherever we could. We reduced the electric difference of potential from something like 80 to 100 milli-volts to less than I could read with my milli-volt meter, which is guaranteed to be tested to 0.2 of one milli-volt.

This local action, due to currents set up by strains in the pipes, as well as leakage of current, can, to a large extent, be overcome by grounding. The whole system should be gone over to find out whether wiring is in contact with the brine system or whether the iron conduits carrying electric wires are in any way grounded to the brine system.

Roderick H. Tait.—The fact that we have a system made up of a good many different units, and we know the pipe was strained in screwing in, and we know those strains are there, makes us wonder what to do about it.

M. B. Smith.—I believe that that destructive action will be in proportion to the amount of strain which is induced; in other words, in designing coils and things like that I believe that the pipe should

be cut as near the proper length as possible and not be made too long or short—not trying to fit a long pipe into a short space, or vice versa.

Roderick H. Tait.—I think the strain due to screwing a pipe into the fittings would amount to more than any strain that could be imposed in making the pipe come into place.

M. B. Smith.—Yes; the torsional strain is far worse than the tensile strain.

Roderick H. Tait.—It does not seem possible to me that grounding would stop local action.

M. B. Smith.—I don't believe local action is stopped altogether by grounding. Perhaps I may be mistaken in that. Only I do believe that local action is, to a certain extent, cumulative. I mean that, in the instance which I have cited, we found the electric difference of potential was built up as we went up the building. I do not know whether that was due to the cumulative effect of the local action or whether it was due to the fact that we kept getting more and more leakage into the system from stray currents. But after they had grounded their brine lines and apparatus they had absolutely no trouble with their brine system, so far as I know.

Albert Johnson.—Mr. Smith stated in this paper that ammonia in the brine solution does not hasten the corrosive effect of the brine on the cans. But I find that in many cases in my own experience it does hasten the corrosive effect. I have seen ice cans lose their galvanizing in a year, or in a year and a half, just from getting a little ammonia in the brine.

M. B. Smith.—Are you speaking of calcium chloride? I mean calcium chloride containing only the merest traces of magnesium chloride running away out into the thousandths of one per cent, and not over one per cent of sodium chloride.

Albert Johnson.—No, I didn't go into that at all; all I know is the general effect an ammonia leak has in brine. It knocks the galvanizing off of cans.

M. B. Smith.—I have yet to find a case in all the ice plant work I have seen where we have had trouble with a brine composed of chlorides such as I have mentioned. I know that magnesium chloride has a very great hastening effect on corrosion.

Albert Johnson.—I have seen cases where engineers have thrown away $500 worth of brine just because they had cans ruined before and did not want to ruin a new set. They put it in the sewer.

M. B. Smith.—I can mention a case in Philadelphia where they are manufacturing ice by the can system. They divided their plant

into two parts to make a comparative test. They put a brine made of one chloride into one part of the system, a brine made of another chloride into the other part of the system. Now, the difference in those chlorides was in the content of magnesium chloride and sodium chloride, one brine containing only a mere trace of magnesium chloride and not over one per cent of sodium chloride, whereas the other line was made from chlorides running as high as 16 per cent of magnesium chloride, and anywhere from three to six per cent of sodium chloride. In that case the galvanizing was stripped from the cans, but it was only in the case of the brine which contained magnesium chloride and sodium chloride. I know that the cans are still in use which had been in the brine containing practically no magnesium chloride and sodium chloride.

Albert Johnson.—Sodium chloride, or common salt? If we get a leak of ammonia into the common salt brine that will knock the galvanizing, won't it?

M. B. Smith.—I don't know.

Albert Johnson.—Or assist corrosion?

Albert Ruemmeli.—Yes, it does.

M. B. Smith.—As I said in answer to Mr. Ruemmeli's statement, the experiments which were carried on were with relatively small amounts of ammonia. It is barely possible that our experiments were not carried out with sufficient ammonia present to show the actual condition in practice. We had samples for analysis of a brine which was sent to us as having hastened corrosion. We made an actual test to find the total ammonia present, the free ammonia and the fixed ammonia, and that brine as we received it certainly showed very slight corrosive effect under, you might say, the worst possible conditions where we were actually driving a current through the brine.

Albert Johnson.—If you can get up a solution which will neutralize this brine when ammonia gets in, you will confer a favor on a great many engineers.

M. B. Smith.—Neutralize the ammonia?

Albert Johnson.—Yes. It has a corrosive effect; we want to neutralize that effect.

M. B. Smith.—Dr. Cushman, in Washington, has been working along somewhat similar lines, but not especially with regard to the presence of ammonia. He has been adding bichromate of potash to the solution, with the idea that it will render any salts present in

the solution passive, so far as local electric action is concerned. So far he has not met with any success.

President Friedmann.—Mr. Ashton, Mr. Ruemmeli has told me that you have some information on this subject which evidently you are willfully withholding.

Walter S. Ashton.—If he will specify what it is I will give it.

President Friedmann.—He says you know of cases where this took place.

Walter S. Ashton.—I know of one case in regard to sodium chlorides where we had a leak in the brine tank of an ice making plant, and it corroded the cans very rapidly. We took the question up with Dr. Luedeking. He advised us to add a certain amount of muriatic acid to the brine, and we did so, and the corrosion stopped.

M. B. Smith.—I think that would be perfectly safe unless you added too much hydrochloric acid.

Walter S. Ashton.—We gave him a sample of the brine, and he instructed us how many pounds of muriatic acid to put into the quantity we had.

M. B. Smith.—That is all right, if you do it under competent direction. Otherwise, you would run into the acid condition, which would be worse than the slightly alkaline condition.

Albert Johnson.—Will phenolphthalein detect ammonia in brine?

M. B. Smith.—If you have any alkali present, no matter what alkali it is, it will give you a pink color, regardless of whether it is ammonia, caustic soda, or perhaps milk of lime, or, in fact, any alkali. I am thoroughly convinced that all brine should be kept slightly alkaline by the addition of caustic soda or milk of lime, which will form a slight sludge, but not in sufficient amount to interfere with pumping operations.

No. 93

Discussion of the Topic—WHAT IS THE MEANING OF THE TERM "USUAL WEAR AND TEAR" IN CONTRACTS FOR REFRIGERATING MACHINERY?

President Friedmann.—I suppose you all know this is one of the terms by which the contractor or manufacturer guarantees certain things. Now, that expression, "usual wear and tear," in my opinion, is very indefinite, and I would like to be enlightened as to just what it really means.

Theodore O. Vilter.—As I look at it, the wear and tear of a plant takes into consideration the depreciation. In other words, I have a machine shop, and in the machine shop I have a number of tools, and some of the tools wear out and are practically useless after five years, while others will run twenty-five years. Consequently, the depreciation has to be figured in each case a little differently. And that applies also to refrigerating and ice-making plants. One man uses his machine about six months full time, 24 hours a day. The other man uses his machine six months full time, three months half time, and three months it stands idle. And the next man uses his machine 365 days in the year. The wear and tear, as you call it, varies, and the local conditions prevailing in the individual plant must be taken into consideration. You cannot have a uniform wear and tear charge for all plants.

Thomas Shipley.—As I understand this question, the term "usual wear and tear" in contracts for ice-making and refrigerating machinery has relation to the wear and tear, or breakage, that comes from the operation of such machinery. Just what comes within the scope of this term is often questionable, for it is hard to draw the exact lines so as to divide wear and tear from defective material and bad workmanship on one side and careless and negligent operation on the other side.

Ice-making and refrigerating machinery is operated more hours per year under full load than average machinery; in fact, it can be classed among the hardest-worked machinery built. Therefore, it is subject to more than ordinary wear and tear and a greater possibility of accidental breakage. No machinery built is so well de-

signed, made of such good material, or has such good workmanship entering into its construction. These are the reasons that they can be operated under full load almost indefinitely without being liable to breakages and extraordinary wear and tear.

The most careful engineer is liable to draw up a box too tight, causing the bearing to heat, and thereby damaging the machine he is operating, or he may allow the bearings to run a little too loose, or he may draw the economy line a little too fine and cause trouble by either using too little oil or too cheap oil, and thus bring about trouble which will increase the wear and tear on the machinery. Since it is impossible for any man to know exactly what condition prevails in all parts of the machinery he is operating, the most careful engineer may have trouble from causes beyond his control. Especially is this a fact when the plant is being crowded, for at such times the boilers are apt to throw over water with the steam, which is very likely to cause damage, and at other times, when the machinery is running light, the pressure in the steam cylinder may drop below the pressure in the exhaust line, and thereby draw any water which the exhaust pipe may contain back into the cylinder, and in this manner cause serious trouble. These troubles do not always show up at the time when they occur, and oftentimes are not known to exist until long afterward when they are shown up by some overload. And again, dirt and grit may be drawn into the bearings from the atmosphere. This may cause the bearings to heat and cut, despite the fact that the regular amount of oil has been used.

The fact that ice-making and refrigerating machinery runs 24 hours a day is one reason why a chief engineer, be he ever so careful, cannot be sure that the plant is operated under the very best conditions at all times; and since this kind of machinery is affected materially by changes in atmospheric conditions, a plant may be overloaded, or it may be run under other conditions conducive to damage without the knowledge of the chief engineer. Since it is a fact that ice-making and refrigerating machinery is subject to more than ordinary wear and tear, the breakages and damages incident to wear and tear cannot be compared with that of ordinary machinery. The manufacturer cannot be held liable for brakages which come from such causes, as they are not conditions which are covered by his guarantee.

For example, if by reason of a shock from water coming into a steam cylinder some part of the mechanism is overstrained, and at

that time, or some future time, it breaks, or causes the breaking of other parts of the machinery, it cannot be held that the manufacturer is liable for such accidents, for the reason that they are caused by the ordinary operation of the machinery. All this kind of machinery in operation is liable to such accident, even under ordinarily careful and competent engineers, and it is to cover such accidents and such wear and tear that the prudent purchaser or owner sets aside a certain percentage of the cost of his machinery each year so that he may equally distribute the burden of such wear and tear over a term of years.

It is my opinion that the manufacturer's liability is limited to those defects which are latent and cannot be seen at the time the machinery is installed, but which do show up during the guarantee period. These defects are usually within the walls of castings, caused by slipping of cores or by blow-holes. If the material used by the manufacturer is not of the proper strength for such purpose, then the manufacturer is liable, provided the damage occurs within the guarantee period.

Another common latent defect for which the manufacturer or seller is responsible is shrinkage cracks in castings. These cracks are caused from extraordinary strains, set up in the castings at the time they are made. These may not show up for some time after the machinery is put in operation, and are among the defects which are covered by the manufacturer's guarantee. Shrinkage cracks in castings, however, must not be confused with cracks caused by overdue strain. At times it is very hard to distinguish between shrinkage cracks and a crack caused by operating strains. Usually, however, the cause can be determined by a careful examination of the surroundings; for example, the foundations may have given away, or the machine may not have been erected properly, thereby causing excessive strain upon the casting and consequent cracks. If, however, it is found that the foundations are solid and the machine is in line, it is evidence that the cracks come from shrinkage.

Of course, we are aware of the possibility of cracking a casting by excessive strain caused by bolting two parts together. This may be the result of carelessness, or it may be the result of defective design, for both of which the manufacturer is liable, provided he erects the machinery himself.

In my opinion, a purchaser cannot refuse to accept machinery for any defects or alleged defects in design, provided the design of the machinery delivered is the same as was sold him; but if the

machinery is really defective in design, so that it will not perform the duties guaranteed, the seller will, of course, be responsible to the buyer for such defects, and if by reason of such defects any part of the machinery should fail within the guarantee period, the seller will be bound to replace such part, provided it occurred within the guarantee period.

President Friedmann.—I fully agree with Mr. Shipley. It is very hard to determine what the term means. It seems to me it is one of those terms put in for lack of something better. "Usual wear and tear," to a certain extent, will, of course, depend on the personal equation of the engineer running the plant. We all know that you can put up a plant as good as can be installed and some fellow will come along who does not know how to run it and ruins it in two days.

Victor H. Becker.—That is unusual wear and tear.

Peter Neff.—I do not think it is a depreciation charge; it is foreign to depreciation. You will find, I think, in almost all contracts that that expression follows directly after the guarantee of the workmanship of the machine as against defects being inherent; they may be in the material itself and unknown to the manufacturer. It is simply a guarantee against that, nowadays, in order to protect a man. I think it is not confined to the ice-machine men. They use that expression, "usual wear and tear," and it simply expresses the intent of the manufacturer to guarantee his apparatus against those defects which are not apparent. For example, you put in a shaft that breaks, and you find that there is a defect in the material. I have never run up against any rulings of the courts on that particular expression. In my mind it has always been a qualifying phrase against defects in material.

P. DeC. Ball.—Wear and tear in a refrigerating or ice-making plant would be the natural wasting away of the crosshead pin, brasses, the piston rings, the valves on the sides, the corrosion of the condensers, and the wearing out of the ice cans, which would come only from the actual use of the material by competent people. I should say a compressor depreciates seven per cent.; that would be good for fifteen years; the ice cans, fifteen per cent.; expansion coils, five per cent.—they never wear out; ammonia condensers, depend entirely on the conditions; they will run from one year to thirty. We all, I think, guarantee our outfits for twelve months, the usual wear and tear excepted.

J. S. Louis.—I quite agree with Mr. Ball with respect to the per cent. of depreciation on the different parts of a plant, although

I usually put the machinery down at about six per cent. But it is a question that is absolutely impossible to answer in an intelligent manner at all; it would seem to me that the best means of getting a correct answer, or an answer from which we might be able to draw some conclusion, would be a court of inquiry. Expert testimony alone would give us an accurate definition of the usual wear and tear on ice-making machinery.

Now, as regards the condenser, it depends entirely upon local conditions of wear and tear, the location, the usual atmospheric conditions, and so forth. The wear and tear upon the seacoast is a great deal more than inland, and there is so much flexibility to the question that I was really surprised when I read it on the program, because it is absolutely impossible to come to any conclusions as to what the usual wear and tear is.

We never put it in our ice-machine contracts, and I do not believe many companies do, because it would just be an invitation to very serious and expensive law suits in a case where the manufacturer might be fighting with a customer, because you could not draw any correct conclusions in the mind of a judge as to what is usual wear and tear. It would depend entirely on the lawyer cross-examining the expert witness. It seems to me that after you have heard from the manufacturers it would be a good thing to hear from the consulting engineers as to what they think usual wear and tear would be, and put it up to a court of inquiry to find out.

Henry Vogt.—Our custom is to insert in contracts "usual wear and tear excepted," and we duplicate any defective material. We may get a bad piece of pipe or sandholes in castings.

PROCEEDINGS

OF THE

SEVENTH ANNUAL MEETING

New York, N. Y., December 4, 1911.

The American Society of Refrigerating Engineers held its seventh annual meeting in the Engineering Societies Building, 29 West Thirty-ninth street, New York, N. Y., on Monday, December 4, 1911. Two sessions were held, Monday morning and afternoon, both being presided over by President E. N. Friedmann, New York, N. Y.

First Session.

The first session was called to order at about 10.30 o'clock A. M., and, after a few words of greeting to the members, President Friedmann announced that it was evident that more than a quorum was present and that a motion would be in order to dispense with the roll call. A motion prevailed to this effect.

The minutes of the sixth annual meeting and the St. Louis meeting were read and approved. The minutes of the St. Louis meeting follow, while the minutes of the sixth annual meeting are printed in the Proceedings of the Second Western Meeting on another page of this volume:

MINUTES OF THE SPECIAL MEETING OF THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS HELD IN ST. LOUIS, MO., ON OCTOBER 2, AND 3, 1911.

The American Society of Refrigerating Engineers held a special, the second Western, meeting in the Jefferson Hotel, St. Louis, Mo., on Monday and Tuesday, October 2 and 3, 1911. Four sessions were held, Monday morning and afternoon and Tuesday morning and afternoon, all being presided over by President Edward N. Friedmann, New York, N. Y. About 125 members and guests were in attendance.

FIRST SESSION, MONDAY MORNING, OCTOBER 2.

The first session of the meeting was called to order at about 11 o'clock on the morning of October 2, and as there was more than a quorum present, the calling of the roll of membership was dispensed with and the business of the meeting taken up.

The minutes of the sixth annual meeting were read and approved.

Two reports of the Tellers of Election of Membership were now received. They reported that the following applicants had been elected to membership in the Society since the sixth annual meeting.

MEMBERS.

F. M. Aday, New York, N. Y.
C. E. Allison, New York, N. Y.
Norman H. Armour, Chicago, Ill.
Charles G. Armstrong, New York, N. Y.
John Hague, St. Louis, Mo.
F. W. Langley, Los Angeles, Cal.
Frederick L. Pryor, Hoboken, N. J.
E. T. Williams, New York, N. Y.
E. W. Gallenkamp, Jr., St. Louis, Mo.
J. Laichinger, St. Louis, Mo.
Louis B. Von Weise, St. Louis, Mo.
George E. Wells, St. Louis, Mo.

ASSOCIATE MEMBERS.

Ellsworth L. Long, New York, N. Y.
L. A. Roy, Chicago, Ill.
William H. Bower, Philadelphia, Pa.
R. E. Bridgette, Brooklyn, N. Y.
William Meeske, New York, N. Y.
H. Richmond, New York, N. Y.
Charles W. Rodgers, New York, N. Y.
C. E. Rose, Little Rock, Ark.
C. L. Whittemore, St. Louis, Mo.

JUNIOR MEMBERS.

Charles F. Schulte, St Louis, Mo.

President Friedmann declared the successful applicants duly elected in their respective grades. He also urged the members to work to still further increase the membership.

Under the heading of new business, invitations to co-operate with the Eighth International Congress of Applied Chemistry and the Sixth Congress of the International Association for Testing Materials were read and referred to the President with power to act.

The next order of business was a paper by President Friedmann on "Advantages of Operating Ammonia Compressors by Aid of Thermometers," which was generously received, with Vice-President Albert Ruemmeli, St. Louis, Mo., in the chair.

At this point Vice-President Ruemmeli introduced Robert Burkham, as representing Mayor Frederick Kriesman, who delivered an address of welcome to St. Louis, which was very cordially received. A suitable response was made by President Friedmann.

The session now adjourned for luncheon as guests of the St. Louis members of the Society and their friends.

SECOND SESSION, MONDAY AFTERNOON, OCTOBER 2.

The second session of the meeting was called to order about 1.30 o'clock P. M.

Henry Torrance, Jr., Chairman of the Cold Storage Legislature Com-

mittee, made a report by telegraph of the work of his committee, which was accepted and the committee continued.

The Merchants Exchange of St. Louis extended an invitation to the members to visit the Exchange during their sojourn in St. Louis, and the Union Electric Light & Power Co. also extended an invitation to the members to visit its plant. President Friedmann thanked the representatives of both institutions for their generous invitations.

The papers presented at this session were: "Problems Encountered in the Design and Construction of an Ammonia Compression Test Plant," by Van Rensselaer H. Greene, New York, N. Y., and "Steel Pipe versus Wrought Iron Pipe in Refrigerating Work," by P. DeC. Ball, St. Louis, Mo.

The topic, "What is the Meaning of the Term 'Usual Wear and Tear' in Contracts for Refrigerating Machinery?" was also discussed at this session.

The session then adjourned for a delightful automobile ride about the parkways of St. Louis and a splendid dinner at Sunset Inn, the old U. S. Grant farm, as guests of the St. Louis members. Theodore O. Vilter, Milwaukee, Wis., acted as toastmaster and addresses were made by President Friedmann; Vice-President Ruemmeli; John Laird, St. Louis, Mo.; George T. Tansey, St. Louis, Mo.; William Reedy, St. Louis, Mo.; Louis Block, New York, N. Y.; Victor H. Becker, Chicago, Ill.; Albert Widmann, St. Louis, Mo.; Thomas Shipley, York, Pa.; Henry Vogt, Louisville, Ky.; J. J. Wuertenbaecher, St. Louis, Mo.; Peter Neff, Canton, Ohio; J. F. Nickerson, Chicago, Ill.; and W. S. Ashton, St. Louis, Mo.

Third Session, Tuesday Morning, October 3.

The third session of the meeting was called to order about 10 o'clock A. M., and the first order of business was the presentation of a letter from W. L. Holzbaur, Kansas City, Mo., on the committee appointed to represent the Society at the Third National Conservation Congress. Mr. Holzbaur stated that the Society was properly represented at the Congress and briefly stated the work of the Congress.

A telegram of greeting and regret was read from Dr. J. E. Siebel, Chicago, Ill.

The papers read at this session were: "Cold Storage Legislation—State and Federal," by R. H. Switzler, St. Louis, Mo., and "The High Speed Ammonia Compressor," by Theodore O. Vilter, Milwaukee, Wis., and a lecture on "Cooling Towers," by Albert Ruemmeli, St. Louis, Mo.

A vote of thanks was extended Mr. Switzler for his very interesting paper.

The session then adjourned for luncheon as guests of the St. Louis members.

Fourth Session, Tuesday Afternoon, October 3.

The fourth and final session of the meeting was called to order at about 1.30 o'clock P. M., and a paper on "The Protection of Refrigerating Apparatus Against Corrosion," by Morgan B. Smith, Syracuse, N. Y., was presented at this session. A vote of thanks was extended Mr. Smith for his very valuable contribution to the data of the Society.

Jacob T. Wainright, Chicago, Ill., also made a few remarks on "A Thermodynamic Phenomenon."

A hearty vote of thanks was extended the St. Louis members of the Society and their friends for the splendid entertainment they had given the members and guests during the meeting.

The meeting then adjourned, followed by an automobile trip and inspection of the brewery and ice manufacturing plant of the Anheuser-Busch Brewing Association.

(Signed) W. H. Ross, *Secretary.*

The next order of business was the report of the Tellers of Election of Membership. They reported as follows:

NEW YORK, N. Y., November 28, 1911.

MR. EDWARD N. FRIEDMANN, President,
The American Society of Refrigerating Engineers,
154 Nassau Street, New York, N. Y.

DEAR SIR:—Your Tellers of Election of Membership have canvassed the ballots for new members closing November 27, 1911, and beg to report that the following applicants have been elected to membership in the society in the grades indicated:

MEMBERS.

Ferdinand Bauer, St. Louis, Mo.
Herbert L. Borchers, St. Louis, Mo.
Ichizo Hoshino, Tokyo, Japan.
B. F. Qualtrough, Kansas City, Mo.
George P. Richardson, Newark, N. J.
Torata Takahashi, Tokyo, Japan.

ASSOCIATE MEMBERS.

Oscar Dreyer, Saratov, Russia.
George A. Horne, New York, N. Y.
Joseph Seigle, Cincinnati, Ohio.
Morgan B. Smith, Syracuse, N. Y.
Constantin Tihotsky, St. Petersburg, Russia.

JUNIOR MEMBERS.

Charles G. Bachniski, Milwaukee, Wis.
John Hill, York, Pa.
W. John Hoffmann, Hoboken, N. J.
Alexander H. Luedicke, Milwaukee, Wis.
E. A. Phillips, Philadelphia, Pa.
George O. Weddell, Philadelphia, Pa.

We also have to report that Waldemar R. Kremer has been advanced in membership from Junior Member to Member.

Respectfully submitted,

(Signed) L. HOWARD JENKS, Chairman, ROBERT N. BAVIER. } *Tellers of Election of Membership.*

President Friedmann then declared the successful applicants duly elected to membership in their respective grades and entitled to the rights and privileges of membership if they had complied with

the provisions of the Constitution and By-Laws governing new members.

The report of the Council was next in order and it was heard and accepted. It follows:

REPORT OF THE COUNCIL OF THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS FOR THE YEAR ENDING DECEMBER 3, 1911.

The amount of real and personal property owned by the Society, the property acquired during the year, the amount applied, appropriated or extended, and the purposes for which such expenditures have been made are contained in the report of the Finance Committee which follows:

NEW YORK, N. Y., December 2, 1911.

MR. EDWARD N. FRIEDMANN, President,
The American Society of Refrigerating Engineers,
154 Nassau Street, New York, N. Y.

DEAR SIR:—Your Finance Committee begs to report as follows for the fiscal year ending December 2, 1911:

Balance on hand December 2, 1910		$468.24
RECEIPTS.		
Initiation fees	$145.00	
Dues	1,979.93	
Emblems, sales	16.50	
Dinner tickets	276.50	
Transactions, sales	35.00	
Total		2,452.93
Grand total		$2,921.17
DISBURSEMENTS.		
Furniture	$9.00	
Printing	640.42	
Caterers	316.00	
Rents	302.15	
Salaries	725.00	
Emblems	27.00	
Membership Certificates	3.75	
Stenographic reports of meetings	296.92	
Miscellaneous	172.50	
Petty cash	210.58	
Total		2,703.32
Balance on hand		$217.85

Respectfully submitted,
(Signed) LOUIS BLOCK, *Chairman.*

The Council held three executive sessions, June 14, August 16, and October 25, during the year, and it respectfully presents herewith a report of the business transacted, along with other matters that should be of interest to the membership.

At the meeting of the Council on June 14, Carl Behn, New York, N. Y., was elected a Director to fill the unexpired term of President Friedmann.

At the meeting of the Council on July 14, W. H. Ross was reappointed Secretary of the Society.

President Friedmann made the following committee appointments on June 1, 1911:

MEMBERSHIP COMMITTEE.

Thomas Shipley, Chairman, York, Pa.
Louis Doelling, New York, N. Y.
N. H. Hiller, Carbondale, Pa.

FINANCE COMMITTEE.

Louis Block, Chairman, New York, N. Y.
Louis Doelling, New York, N. Y.
Charles Dickerman, Philadelphia, Pa.

PUBLICATION COMMITTEE.

Charles E. Lucke, Chairman, New York, N. Y.
W. H. Manns, Waynesboro, Pa.
Gardner T. Voorhees, New York, N. Y.

PROGRAM COMMITTEE.

Louis Doelling, Chairman, New York, N. Y.
Louis Block, New York, N. Y.
Charles E. Lucke, New York, N. Y.
Albert Ruemmeli, St. Louis, Mo.
Thomas Shipley, York, Pa.

NOMINATING COMMITTEE.

Carl Behn, Chairman, New York, N. Y.
D. S. Jacobus, New York, N. Y.
J. F. Nickerson, Chicago, Ill.
Herbert Nulsen, New York, N. Y.
J. H. Stone, New York, N. Y.

TELLERS OF ELECTION OF MEMBERSHIP.

L. Howard Jenks, Chairman, New York, N. Y.
Robert N. Bavier, New York, N. Y.
Frank A. Horne, New York, N. Y.

On invitation of the Joint Committee Representing Cold Storage Warehousemen and Affiliated Industries, under date of April 29, 1911, to have a representative of the Society on this Joint Committee, President Friedmann appointed Henry Torrance, Jr., Chairman of the Cold Storage Legislation Committee to represent the Society.

At the meeting of the Council on June 14 a resolution carried authorizing a special meeting of the Society to be held in St. Louis, Mo., on Monday and Tuesday, September 25 and 26, 1911. At the meeting on August 16 the dates of the St. Louis meeting were postponed to October 2 and 3, to fit in with the dates of the Veiled Prophets Festival in St. Louis. President Friedmann appointed Albert Ruemmeli, R. H. Tait, J. C. Atwood, F. Widmann and V. H. Becker, Jr., as a Special Entertainment Committee to arrange the local details of the meeting.

By resolution of the Council, President Friedmann appointed Walter C. Reid, John A. Ruddick and John E. Starr as a Resolutions Committee to draft resolutions on the death of members during the year.

Louis Block, President Friedmann and W. H. Ross were appointed as a committee to solicit subscriptions from the membership of the Society for the Entertainment Fund of the Third International Congress of Refrigeration, by resolution of the Council.

A motion prevailed at the meeting of the Council on June 14, authorizing the President to appoint a Special Membership Committee to secure new members for the Society, with the President as chairman. President Friedmann named Walter C. Reid, Louis Block and W. H. Ross as the other members of this committee.

The Donating Membership of the Society in the American Association of Refrigeration entitles it to a representative on the Advisory Board of the American Association of Refrigeration, and President Friedmann appointed Henry Vogt, Louisville, Ky., to represent the Society on this Advisory Committee.

The following applicants have been elected to membership in the Society during the year in the grade indicated:

MEMBERS.

F. M. Aday, New York, N. Y.
C. E. Allison, New York, N. Y.
Norman H. Amour, Chicago, Ill.
Charles G. Armstrong, New York, N. Y.
John Hague, St. Louis, Mo.
F. W. Langley, Los Angeles, Cal.
Frederick L. Pryor, Hoboken, N. J.
E. T. Williams, New York, N. Y.
E. W. Gallenkamp, Jr., St. Louis, Mo.
J. Laichinger, St. Louis, Mo.
Louis B. Von Weise, St. Louis, Mo.
George E. Wells, St. Louis, Mo.
Ferdinand Bauer, St. Louis, Mo.
Herbert L. Borchers, St. Louis, Mo.
Ichizo Hoshino, Tokyo, Japan.
B. F. Qualtrough, Kansas City, Mo.
George P. Richardson, Newark, N. J.
Torata Takahashi, Tokyo, Japan.

ASSOCIATE MEMBERS.

Ellsworth L. Long, New York, N. Y.
L. A. Roy, Chicago, Ill.
William H. Bower. Philadelphia, Pa.
R. E. Bridgette, Brooklyn, N. Y.
William Meeske, New York, N. Y.
H. Richmond, New York, N. Y.
Charles W. Rodgers, New York, N. Y.
C. E. Rose, Little Rock, Ark.
C. L. Whittemore, St. Louis, Mo.
Oscar Dreyer, Saratov, Russia.
George A. Horne, New York, N. Y.
Joseph Seigle, Cincinnati, Ohio.
Morgan B. Smith, Syracuse, N. Y.
Constantin Tihotsky, St. Petersburg, Russia.

JUNIOR MEMBERS.

Charles F. Schulte, St. Louis, Mo.
Charles G. Bachniski, Milwaukee, Wis.
John Hill, York, Pa.
W. John Hoffman, Hoboken, N. J.
Alexander H. Luedicke, Milwaukee, Wis.
E. A. Phillips, Philadelphia, Pa.
George O. Weddell, Philadelphia, Pa.

Waldemar R. Kremer, Milwaukee, Wis., has been advanced in membership from Junior Member to Member.

Fourteen applications for membership are receiving the attention of the Membership Committee.

The resignations from membership of the following members have been accepted by the Council with regret:

R. C. Carpenter, Ithaca, N. Y.
Oswald Gueth, Brooklyn, N. Y.
J. W. Birkholz, Medford, Ore.
Fred Nolde, Fairview Village, Pa.
C. E. Bonnell, Chicago, Ill.
Allston Sargent, New York, N. Y.
J. J. Hinde, Cleveland, Ohio.

The Council regrets to report the death of the following members during the year and hopes that suitable resolutions will be passed on their lives during this meeting:

L. M. Tough, Baltimore, Md.
O. M. Gould, Montreal, Can.

On invitation of the President of the Third National Conservation Congress, that was held in Kansas City, Mo., September 25 to 27, 1911, to have the Society represented at this congress, President Friedmann appointed G. F. Bein, Kansas City, Mo.; William Nottberg, Kansas City, Mo.; W. L. Holzbaur, Kansas City, Mo.; Eugene F. McPike, Chicago, Ill., and L. C. Nordmeyer, St. Louis, Mo., to represent the Society. The report of the delegates was read at the St. Louis meeting of the Society.

The Society has been asked to co-operate with the Eighth International Congress of Applied Chemistry that will be held in Washington and New York in September, 1912, and the Sixth Congress of the International Association for Testing Materials that will be also held in New York in September of 1912. The St. Louis meeting of the Society referred these invitations to the President, with power to act.

Volume IV of the "Transactions" has been recently issued and Volume V will probably be issued around February 1, 1912, and Volume VI will probably be issued about July 1, 1912.

Your President has appointed the following members as Tellers of Election of Officers: Walter L. Hill, W. H. Bower and William Hargreaves.

Respectfully submitted,

E. N. FRIEDMANN, *President.*

The next order of business was unfinished business, and under this heading Henry Torrance, Jr., made a report for the Cold Storage Legislation Committeee. He reported that his committee had been represented at the hearing on the proposed New York State cold storage law, and had been generally active in co-operating with similar committees of other bodies. The report was accepted and the committee continued.

Under unfinished business a report was also received from the Special Membership Committee. The report for this committee was

made by President Friedmann, who stated that the committee had sent personal letters to all the members of the Society, and that the response was very gratifying, as was evidenced by the increase in membership during the year. The committee was discharged with thanks.

Under unfinished business there was also received the report of the Resolutions Committee. The report was presented by John E. Starr. It follows:

OVID M. GOULD.

Ovid M. Gould, general manager of the Gould Cold Storage Company of Montreal, Canada, a valued member of The American Society of Refrigerating Engineers, passed away on February 21, 1911.

While Mr. Gould bore an enviable reputation as a business man for the highest integrity and ability, those who knew him best will recall with pleasure his sympathetic nature and affectionate disposition.

Mr. Gould was of an inventive turn of mind, and his elevator device for the rapid loading and unloading of packages and improvements in cooling towers have been of much value to refrigerating interests.

Resolved, therefore, That The American Society of Refrigerating Engineers take this occasion to express to the relatives of Mr. Gould and his colleagues in the Gould Cold Storage Company its appreciation of his valued services in the refrigerating industry, his integrity of character in all business dealings and his sympathy and love at all times for his fellowmen.

Resolved, further, That we extend to them our heartfelt sympathy in their bereavement and that a copy of these minutes be forwarded to his brother and to the Gould Cold Storage Company.

The Resolutions Committee also reported the death of L. M. Tough, Baltimore, Md.

The consideration of new business was next in order, and W. H. Ross proposed amending paragraphs C 20 and C 26 of the Constitution, for discussion and modification at this meeting and final action at the next annual meeting. His proposition follows:

PROPOSED AMENDMENTS TO THE CONSTITUTION OF THE SOCIETY.

To the Seventh Annual Meeting
of
THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS IN CONVENTION ASSEMBLED.

GENTLEMEN:—Pursuant to Section C 40 of our Constitution, relative to amendments to the Constitution of the Society, I propose an amendment to Section C 20 of the Constitution.

Where Section C 20 now reads:

"The affairs of the Society shall be managed bv a Board of Directors chosen from among its Members and Associates, which shall be

styled 'The Council.' The Council shall consist of the President of the Society, who shall be presiding officer, the two Vice-Presidents, Treasurer and nine Members or Associates. Seven members of the Council shall constitute a quorum for the transaction of business. The Secretary may take part in the deliberations of the Council, but shall not have a vote therein."

I would have it read:

The affairs of the Society shall be managed by a Board of Directors chosen from among its Members and Associates, which shall be styled "The Council." The Council shall consist of the President of the Society, who shall be the presiding officer, the two Vice-Presidents, Treasurer and *fifteen* Members and Associates. Seven members of the Council shall constitute a quorum for the transaction of business. The Secretary may take part in the deliberations of the Council, but shall not have a vote therein.

This increase in the number of Directors also necessitates an amendment to Section C 26 of the Constitution. So where the fifth paragraph of Section C 26 reads:

"Nine Members or Associates shall be elected to the Council at the first Annual Meeting, three to hold office for one year, three to hold office for two years, and three to hold office for three years, and at each subsequent Annual Meeting three Members or Associates shall be elected, each to serve three yars."

I would have it read:

Fifteen Members or Associates shall be members of the Council, five being elected each year, and each to hold office for three years, with the the exceptions contained in this paragraph. On the year of acceptance of this amendment (1912), and in order to increase the number of Directors from nine, as heretofore, to fifteen, as provided in this paragraph and in amended Section C 20, nine Members or Associates shall be elected to the Council, five to hold office for three years, two to hold office for two years, and two to hold office for one year, thereafter five Members or Associates shall be elected each year.

This amendment shall not affect the term of office of Directors elected prior to its adoption.

I propose these amendments for the best interests of the Society, as the number of members of the Council, as now made up, does not permit of a proper geographical distribution of its members so that a quorum is easily obtainable at its meetings. At the same time there has been a growing feeling for the past several years that The American Society of Refrigerating Engineers is an Eastern organization on account of the members of the Council necessarily residing near the offices of the Society. I offer these amendments to remove and abate this seeming contention, and probably justly so, of some of our Western members, as the increase in membership of the Council will result in a better geographical distribution of its members.

I earnestly hope that these amendments will receive the unanimous approval of the membership of the Society.

W. H. Ross, *Proposer.*

The report of the Tellers of Election of Officers was next in order. It was as follows:

NEW YORK, N. Y., December 4, 1911.

MR. EDWARD N. FRIEDMANN, President,
The American Society of Refrigerating Engineers,
154 Nassau Street, New York, N. Y.

DEAR SIR:—Your Tellers of Election of Officers beg to report that we canvassed the ballots for officers this morning and find that there were 125 ballots cast for the offices falling vacant at the close of this, the seventh, annual meeting.

		Votes.
President—	Thomas Shipley	123
	Louis Block,	1
Vice-President—	Henry Torrance, Jr.	124
	Carl Behn	1
Treasurer—	Frank A. Horne	125
Directors—	Theodore O. Vilter	125
	Victor H. Becker	124
	Karl Vesterdahl	1
	J. J. Wuertenbaecher	1
	Charles L. Case	124

We, therefore, finally report that the following have been duly elected to the offices in question:

President—Thomas Shipley.
Vice-President—Henry Torrance, Jr.
Treasurer—Frank A. Horne.
Directors—Theodore O. Vilter,
Victor H. Becker.
Charles L. Case.

Respectfully submitted,
(Signed) WALTER L. HILL, Chairman. } *Tellers of Election of Officers.*
W. HARGREAVES.
W. H. BOWER.

President Friedmann appointed ex-Presidents Starr and Penney as a committee to escort President-elect Shipley to a chair beside him.

In accepting the presidency of the Society Mr. Shipley said:

"I certainly appreciate the honor that you have conferred upon me. President Friedmann has stated that he hopes my administration will be as successful as all the other things I have undertaken. I have not been a success in everything that I have undertaken, I assure you, and I may not be successful as your president. I think that the day has gone by when refrigerating machine designers and builders cannot come together under one roof and talk over their problems. I assure you I will do the best I can to continue the good work this Society has started out to do, and I hope all the members will give me their assistance to that end."

The reading and discussion of papers was now taken up. The first was "Compressor Water Jackets," by President E. N. Friedmann, New York, N. Y., with President-elect Shipley in the chair.

The session then adjourned for luncheon, arranged for by the Program Committee.

Second Session

The second session of the meeting was called to order at about 1.30 P. M., and President Friedmann promptly introduced C. W. Waidner, of the Bureau of Standards, Washington, D. C. Mr. Waidner gave an illustrated lecture on "The Work of the Bureau of Standards of Interest to Engineers."

A hearty and unanimous vote of thanks was given Mr. Waidner for his very interesting lecture.

The following papers were also presented at this session:

"The Evaporative Condenser," by J. Beaumont Spencer, New York, N. Y.; "Fruit Precooling Problems," by A. V. Stubenrauch, Washington, D. C.; "The Non-Precipitation of Calcium Chloride from Brine by Ammonia," by Morgan B. Smith, Syracuse, N. Y., and "The Relative Importance of Handling and Refrigeration in the Preservation of Perishable Foodstuffs," by Dr. M. E. Pennington, Philadelphia, Pa.

Votes of thanks were extended Mr. Spencer, Mr. Stubenrauch and Dr. Pennington for their valuable and interesting papers.

Before adjourning a hearty vote of thanks was extended President Friedmann for his valuable services to the Society during his term of office.

The meeting then adjourned.

W. H. Ross, *Secretary.*

MEMBERS AND GUESTS ATTENDING SEVENTH ANNUAL MEETING.

C. E. Allison, New York, N. Y.
Harry T. Bernhard, New York, N. Y.
William H. Bower, Philadelphia, Pa.
R. E. Bridgette, Brooklyn, N. Y.
J. N. Briggs, Coeymans, N. Y.
Louis Block, New York, N. Y.
Peter Binzel, Jr., New York, N. Y.
Richard Broas, New York, N. Y.
Harold W. Cole, New York, N. Y.
Gilbert Crawford, Jr., Washington, D. C.
Clarence W. Cranmer, Philadelphia, Pa.
Edwin D. Dreyfus, Pittsburg, Pa.
Charles Dickerman, Philadelphia, Pa.
R. T. Dulton, New York, N. Y.
Hermann Dannenbaum, Philadelphia, Pa.
A. Day, Bloomfield, N. J.
D. H. Elder, New York, N. Y.
E. N. Friedmann, New York, N. Y.
F. R. Furbish, Carbondale, Pa.
W. L. Gladfelter, York, Pa.
Van Rensselaer H. Greene, New York, N. Y.
W. Hargreaves, New York, N. Y.
A. E. Howe, Philadelphia, Pa.
Walter L. Hill, Boston, Mass.
Charles H. Herter, New York, N. Y.
N. H. Hiller, Carbondale, Pa.

W. John Hoffmann, New York, N. Y.
J. Hill, New York, N. Y.
E. M. Holcombe, Carbondale, Pa.
Frank A. Horne, New York, N. Y.
George A. Horne, New York, N. Y.
George F. Hill, New York, N. Y.
Charles Jonsson, New York, N. Y.
J. V. Jamison, Jr. Hagerstown, Md.
L. Howard Jenks, New York, N. Y.
Theodore Kolischer, Philadelphia, Pa.
Eugene W. Lewis, New York, N. Y.
John R. Livezey, Philadelphia, Pa.
C. E. Lucke, New York, N. Y.
G. W. Langdon, New York, N. Y.
A. Ross Mackay, New York, N. Y.
William Meeske, New York, N. Y.
F. E. Matthews, New York, N. Y.
A. T. Marshall, Hartford, Conn.
William P. Morton, Philadelphia, Pa.
H. S. Newham, New York, N. Y.
J. Neubecker, New York, N. Y.
J. E. Miles, Nyack, N. Y.
Edgar Penny, Newburgh, N. Y.
E. A. Phillips, Philadelphia, Pa.
M. E. Pennington, Philadelphia, Pa.
Thomas Pettigrew, New York, N. Y.
John L. Plock, New York, N. Y.
A. C. Ross, Brooklyn, N. Y.
W. H. Ross, New York, N. Y.
J. P. Reilly, New York, N. Y.
G. P. Richardson, Newark, N. J.
Charles W. Rodgers, New York, N.Y.
Harry Richmond, New York, N. Y.
L. A. Ramsey, New York, N. Y.
T. L. Rankin, Sacket Harbor, N. Y.
Morgan B. Smith, Syracuse, N. Y.
A. B. Strickler, York, Pa.
Thomas Shipley, York, Pa.
S. P. Stevenson, Chester, Pa.
S. F. Smyth, Brooklyn, N. Y.
S. J. Shipley, New York, N. Y.
John C. Sparks, New York, N. Y.
A. V. Stubenrauch, Washington, D. C.
J. Beaumont Spencer, New York, N. Y.
W. S. Shipley, New York, N. Y.
J. W. Sutton, New York, N. Y.
L. Sterne, London, England.
Guy B. Smith, Brooklyn, N. Y.
J. H. Stone, New York, N. Y.
Horace P. Serrill, Philadelphia, Pa.
John E. Starr, New York, N. Y.
George H. Thomson, New York, N.Y.
G. A. Wagner, New York, N. Y.
Fred. A. Weisenbach, Philadelphia, Pa.
George O. Weddell, Philadelphia, Pa.
C. W. Waidner, Washington, D. C.
L. Werliin, Philadelphia, Pa.
E. T. Williams, New York, N. Y.
L. F. Yeakley, Philadelphia, Pa.
H. J. Zehder, New York, N. Y.

THE BANQUET.

The banquet was held on Monday evening, December 4, at the Hotel Victoria, Broadway and Twenty-seventh street, and over 75 gathered around the festive board. A highly enjoyable dinner was served.

Ex-President John E. Starr acted as toastmaster, and addresses were made by President Shipley, ex-President E. N. Friedmann, ex-President Louis Block, A. B. Stubenrauch, Washington, D. C.; Charles E. Lucke, New York, N. Y.; Dr. C. W. Waidner, Washington, D. C.; Thomas L. Rankin, Sackett's Harbor, N. Y.; Theodore Kolischer, Philadelphia, Pa.; W. H. Bower, Philadelphia, Pa.; ex-President Edgar Penney and E. A. Phillips, Philadelphia, Pa.

The addresses were interspersed with songs, music and stories.

The following attended the banquet:

C. E. Allison, New York, N. Y.
Harry T. Bernhard, New York, N. Y.
Louis Block, New York, N. Y.
W. H. Bower, Philadelphia, Pa.
Richard Broas, New York, N. Y.
C. W. Cranmer, Philadelphia, Pa.
Gilbert Crawford, Jr., Washington, D. C.
Hermann Dannenbaum, Philadelphia, Pa.
Charles Dickerman, Philadelphia, Pa.
D. H. Elder, New York, N. Y.
E. N. Friedmann, New York, N. Y.
F. R. Furbish, New York, N. Y.
W. L. Glatfelter, York, Pa.
Van R. H. Greene, New York, N. Y.
Charles H. Herter, New York, N. Y.
John Hill, New York, N. Y.
Walter L. Hill, Boston, Mass.
N. H. Hiller, Carbondale, Pa.
A. E. Howe, Philadelphia, Pa.
E. M. Holcombe, Carbondale, Pa.
J. V. Jamison, Jr., Hagerstown, Md.
L. Howard Jenks, New York, N. Y.
Charles Jonsson, New York, N. Y.
T. Kolischer, Philadelphia, Pa.
G. M. Langdon, New York, N. Y.
Eugene W. Lewis, New York, N. Y.
John R. Livezey, Philadelphia, Pa.
C. E. Lucke, New York, N. Y.
A. R. Mackay, New York, N. Y.
A. T. Marshall, Hartford, Conn.
William Meeske, New York, N. Y.
William P. Morton, Philadelphia, Pa.
H. S. Newham, New York, N. Y.
Edgar Penney, Newburgh, N. Y.
E. A. Phillips, Philadelphia, Pa.
T. L. Rankin, Sacketts Harbor, N. Y.
L. A. Ramsey, New York, N. Y.
George P. Richardson, Newark, N. J.
Harry Richmond, New York, N. Y.
J. P. Reilly, New York, N. Y.
Charles W. Rodgers, New York, N. Y.
A. C. Ross, New York, N. Y.
W. H. Ross, New York, N. Y.
Horace P. Serrill, Philadelphia, Pa.
S. J. Shipley, New York, N. Y.
Thomas Shipley, York, Pa.
William S. Shipley, New York, N. Y.
Guy B. Smith, Brooklyn, N. Y.
Morgan B. Smith, Syracuse, N. Y.
John E. Starr, New York, N. Y.
L. Sterne, London, England.
S. P. Stevenson, Chester, Pa.
J. H. Stone, New York, N. Y.
A. B. Strickler, York, Pa.
A. V. Stubenrauch, Washington, D. C.
W. S. Sutton, New York, N. Y.
George H. Thomson, New York, N. Y.
Charles W. Waidner, Washington, D. C.
George A. Wagner, New York, N. Y.
George O. Weddell, Philadelphia, Pa.
Fred A. Weisenbach, Philadelphia, Pa.
L. Werliin, Philadelphia, Pa.
E. T. Williams, New York, N. Y.
L. F. Yeakley, Philadelphia, Pa.
H. J. Zehder, New York, N. Y.

PAPERS OF THE

SEVENTH ANNUAL MEETING

NEW YORK, N. Y., December 4, 1911

No. 94

PRESIDENTIAL ADDRESS—COMPRESSOR WATER JACKETS.

By Edward N. Friedmann, New York, N. Y.

At the St. Louis meeting I called attention to the advisability, if not the necessity, of furnishing certain data to the operating refrigerating engineer in order to enable him to secure the best results. You will please remember that I did not establish correct tables, or elaborate them, the idea being to let the different makers of compressors furnish such tables for the use of the men operating their own particular type of machine. It stands to reason that, if these data are obtained by tests, they will also apply more or less closely to other machines of similar type, depending on the accuracy of the tests.

In the discussion following the reading of the paper referred to, mention was made of the value of the water jacket, and it was evident that the ideas of some of the engineers present were radically different. As a matter of fact, one of the largest builders has recently changed the design of the water jacket, making it shorter, and even insulating the lower part of the compressor which was formerly surrounded by water.

Now we would like to know the reason for this change—whether it is based on theoretical calculations or on the results of actual tests. If the latter, what conclusions were arrived at; and would the manufacturer be willing to give them to us?

We know that in one of the tests at Rochester (Test No. 3) no water was circulated through the jackets, and no fresh water was added during the test, so that gradually the water left there was evaporated. The cooling of the cylinder was accomplished by the injection of liquid ammonia. The result of this test was that 315.63 pounds of ammonia was circulated in 15 minutes, while the amount in Test No. 1 had been 311.4 pounds with water jacket in use. I do not know whether the above-mentioned change in size and construction of the water jacket was based on these Rochester tests, or whether, since then, additional tests have been made which have led to the new construction of jacket.

The time since our last meeting has been too short, considering my business engagements, to permit of my going into this matter very deeply; and the object of these remarks is, as at St. Louis, merely to draw the attention of the constructors to the unsettled questions of design and use of the water jacket under the varying conditions obtaining in practice. I have found, by questioning engineers in large plants, that none had received instruction or advice as to the proper manipulation of the water jacket, but each one was of the opinion that the water should leave the jacket about lukewarm.

It is certainly of interest to all of us to know what influence the water jacket exerts and the conditions under which it is most useful; also, whether it is best at times not to make use of the jacket. What I should like to see established is some simple rules for the operating engineer—to show him that it is best, under certain conditions, to run all the water he can through the jacket and at the lowest temperature available; also, under what conditions he should stop the flow of water through the jacket.

In considering these problems, not having access to an experimental plant, I was limited to the data established in accurate tests, such as those made at the works of the York Manufacturing Company, or during the celebrated Rochester tests, with which we are all more or less familiar. In reading the discussions and claims of both participants in these tests, you will note that the manipulation of the water jacket was one of the bones of contention; but since these tests, several years ago, the matter has rested, so far as publications are concerned; and while the discussions and expressions of mutual admiration were very interesting at the time, no new data have been established or published, to my knowledge. I have, therefore, had to make use of the data then available.

While studying the data mentioned, I found that certain conditions affecting the use of the water jacket were different in the single-acting and the double-acting compressor, making the influence of the water jacket favorable or unfavorable, according to circumstances. In a double-acting compressor we have, during each stroke, suction on one side of the piston and compression on the other, while in the single-acting compressor we have, during the up-stroke, suction on the bottom and compression at the top; but on the down-stroke we have only the gas passing from the under side of the piston to the top, without either suction or compression. During this down-stroke—which we may call the intermediate stroke, for want of a better name—cooling or heating takes place according to whether the mean temperature of the jacket water is lower or higher than

the temperature of the ammonia inside the compressor. Since there is no intermediate stroke in the double-acting compressor, no such cooling or heating can take place. Now if the mean temperature of the jacket water were above that of the ammonia, the result, of course, would be a rise in the temperature of the ammonia; and this, in my opinion, is the case in the Rochester test No. 3, resulting in a loss. By stopping the water circulation this loss was avoided, in accordance with the result of the test for capacity, as I shall show later.

If this line of reasoning is correct, the following rules for the operating engineer suggest themselves:

First.—Run as much water, and at as low temperature as is available, through the water jacket, in order to maintain a low mean temperature.

Second.—Since the larger the diameter of the compressor the less the inside superheat, and accordingly the greater the chance of heating the ammonia by the jacket water, it seems an advantage to reduce the water jacket as far as possible on the larger compressors—for instance, from 18 to 24 inches in diameter—but to use liquid ammonia injection instead. In the case of smaller compressors, 12 inches or less in diameter, it is my opinion that the water jacket is a very good thing, effecting a greater cooling than is possible in the double-acting compressor not having this intermediate stroke.

As an illustration, we will consider the following three examples taken from tests of a York single-acting compressor:

TEST NO. 1—OCTOBER, 1903 (MADE IN YORK, PA.)

Compressors	Two, 12½ x 18 inches, single-acting, vertical
Discharge temperature	213 degrees Fahr.
Suction temperature	19 degrees Fahr.
Temperature at end of suction stroke*	72 degrees Fahr.
Jacket water, mean temperature of	63 degrees Fahr.
Difference in temperature	9 degrees Fahr.
Area of inner cylinder walls and heads	11 square feet

Product of square feet area and degrees difference in temperature, 11 × 9 = 99, which may be taken to represent the quantity of heat absorbed by the water jacket. In this case the water jacket was beneficial.

TEST NO. 2—MARCH, 1908 (MADE IN ROCHESTER, N. Y.)

Compressors	Two, 15 x 22 inches, single-acting, vertical
Ammonia delivered in 15 minutes by compressor	311.4 pounds
Discharge temperature	216 degrees Fahr.
Suction temperature	15 degrees Fahr.
Temperature at end of suction stroke*	59 degrees Fahr.
Jacket water, mean temperature of	68 degrees Fahr.
Difference in temperature	9 degrees Fahr.
Area of inner cylinder walls and heads	17 square feet

*Figured from Wood's formula $p.\,v = 91\,T - \frac{17000}{v}$

Product of square feet area and degrees difference in temperature, since the heat transmission is about one B. t. u. per square foot per minute per degree difference, or $17 \times 9 = 153$, which may be taken to represent quantity of heat in B. t. u. absorbed by the ammonia from the jacket water.

In this case the water jacket was detrimental. Assuming 500 B. t. u. are absorbed in the evaporation of one pound of ammonia, $153 \div 500 = 0.306$ the number of pounds of ammonia necessarily evaporated to make up for the heat absorbed from the water jacket. In 15 minutes this would amount to 4.59 pounds.

TEST NO. 3—MARCH, 1908 (MADE IN ROCHESTER, N. Y.)

Compressor	Same as in Test No. 2
Ammonia discharged by compressor in 15 minutes	315.65 pounds
Discharge temperature	250 degrees Fahr.
Suction temperature	16 degrees Fahr.
Temperature at end of suction stroke	59 degrees Fahr.
Jacket water	Not circulated

If to 311.4, the number of pounds of ammonia discharged per 15 minutes in Test No. 2, we add the 4.59 pounds required to make up for the water jacket loss, we get 315.99 pounds, the amount that the compressor would be expected to discharge when operating without water circulation through the jackets. The slight difference between this amount and the 315.65 pounds actually discharged may be accounted for by the fact that in Test No. 3 the suction temperature was higher and the suction pressure slightly lower than in Test No. 2.

TEST NO. 4—(MADE IN NEW YORK, N. Y.)

Compressors	Two 21 × 32 inches, single acting, vertical
Discharge temperature	279 degrees Fahr.
Suction temperature	6 degrees Fahr.
Temperature at end of suction stroke	40 degrees Fahr.
Jacket water, mean temperature assumed	90 degrees Fahr.
Difference in temperature	50 degrees Fahr.

In this case the water jacket was particularly detrimental on account of the large cooling surface that the cylinder presents to the warm jacket water.

It is of the greatest importance, in my opinion, that the question when the use of a water jacket is advantageous or disadvantageous be settled by the manufacturers who are in position to have accurate tests made in their special test plants, for it is obvious that the construction of the compressor should be adapted to the particular conditions under which it is to be operated.

In large compressors, from 18 to 24 inches in diameter, and where the cooling water available is of high temperature, from 70 to

90 degrees Fahr., which is often the case under summer conditions, the water jacket is not only of no benefit, but even a detriment, while under the same conditions with small compressors, from 12 inches in diameter down, the water jacket is advantageous.

It is regrettable that the manufacturers' tests have been made under abnormal conditions, the cooling water being what may be termed "winter water," while the condenser pressures were artificially made to correspond to summer conditions. Thus the compressor is surrounded by colder water than would be the case under ordinary summer conditions. This influences both the tonnage of refrigerating capacity and the horsepower consumed per ton. Any reduction of discharge temperature effects a corresponding reduction in horsepower, nearly all of the power put into a compressor being expended in increasing the temperature of the ammonia vapor from that of the cooler to that of the condenser.

DISCUSSION.

Henry Torrance, Jr.—I do not see how the effect of the water jacket is more on large compressors than on small ones. I thought it was the other way.

President Friedmann.—The reason is this; that the internal superheat of the ammonia, as I say, from the suction stroke is in inverse proportion to the diameter. For instance, in the Ebling test the internal superheat increased, I believe, in the neighborhood of 30 or 35 degrees Fahr., while in the 6-inch compressor this increase would go up to 100 degrees and over. That is where the difference comes in between the larger and the smaller compressors; through the difference between the mean temperature of the water jacket and the temperature inside.

Chairman Shipley.—I think Mr. Friedmann ought to say that his reason is the theoretical one, not "the reason." What I am getting at is that the surface of a large compressor is very much less in proportion to the volume of the cylinder than the surface of a smaller one. The surface varies as the diameter and the volume varies as the square of the diameter.

President Friedmann.—Exactly. That is where the superheat comes in.

Chairman Shipley.—But of course the transmission is less. I am comparing the areas through which the cooling effects must be transmitted.

President Friedmann.—But the difference is that in the large

compressor the internal superheat, no matter at what temperature it is, is far less than in the small compressor.

Henry Torrance, Jr.—I will take your word as to its being a fact. You have two variables there, one is tending to make it more and the other is tending to make it less in proportion to the size.

President Friedmann.—Since writing this paper I had a talk with our President-elect and he tells me that they anticipated what I ask for, and many years ago ran a series of tests, and that one of our past presidents was in charge of those tests, a fact which was very interesting to me.

I can only repeat that this paper is not to establish any rules at all, but simply to call attention to one of the points which, as far as I know, has received scant consideration. You can do what I did, ask a hundred engineers running plants, and they all say the same thing. They all agree that, if they stick their hands in the water jacket and find the water warm, it is all right. What I mean is this: I have been trying, as you know, from the last meeting, to get the manufacturers to make tests and publish the results, and they are perfectly willing to do it, it seems. These data are not sufficiently well known to the operating man. On the other hand, if the compressors are constructed in the proper way it may not make any difference, because the size of pipe put in the jacket and coming out of the jacket would naturally give the limit to the amount of water that could be put through. But since these tests are being made I think it would be of great interest to us if now, or at a future meeting, the York Manufacturing Company would let us have the benefit of them.

John E. Starr.—I wish to correct the impression that I had charge of certain tests that Mr. Friedmann speaks of. I did make some observations on this question of jacket water during the tests that were made in Rochester, generally known as the Eastman tests. One day during those tests the water was left standing in the jacket practically filled up to the top of the cylinder, and it occurred to me it would be a good idea to find out what the temperature of that water was. I therefore took a fairly accurate high and low temperature thermometer. There was no immediate means of getting at the constant reading of the temperature of the jacket water without boring through the jacket. With this thermometer, in a rather rough way, I got the temperature of the water at the bottom of the jacket, which was practically at the bottom of the cylinder, at the commencement of the stroke. This was a single acting vertical machine.

The temperatures, as nearly as I can remember them, were about as follows: The water standing in the bottom of the jacket was about 70 degrees Fahr.; at half way of the stroke it was still 70 degrees; at about two or three inches below the point in the stroke, where the discharge valve opened, it rose slightly to, as near as I can remember, 71 or 72 degrees. A little further up, just before the discharge valve opened, the temperature of the water rose rapidly; and at the top of the jacket the temperature was—I hesitate to put a figure on it because my memory is at fault—but it was somewhere in the neighborhood of 180 degrees, and the water was slightly steaming, a slight vapor coming off the water. The only conclusion that could be arrived at in this case was that the gas was refrigerating the jacket water for a considerable portion of the stroke, and, in fact, up to within a short distance of the opening of the discharge valve. If I had known that this paper was to be read I would have posted myself a little more accurately on those figures. I give them from memory and they are approximately right, or at least they indicate what was going on in that particular case.

Chairman Shipley.—Has anybody else anything to say on the subject? If not, I will ask Mr. Friedmann to take the chair and I will say a few words myself.

Mr. President and Gentlemen: I am very much surprised to know that anybody accused the York Manufacturing Company of not telling them about these tests. The fact is we have been so windy about them that I began to be ashamed of myself. So far as the subject of water jackets is concerned, I was under the impression that Mr. Starr once wrote a paper on that subject.

John E. Starr.—I wrote a paper, but not for this Society. I think it was published in "Ice and Refrigeration," or some other publication.

Thomas Shipley.—That is as I remember it. I also remember of Professor Shipman writing a paper on this subject shortly after our tests. He did it with my consent; in fact, partly under instructions, for the simple reason that we wanted to bring it before the public. We wanted to show that we had an excuse for changing the design of our water jackets. We found out that jacket water was a detriment to the efficiency of the compressor; that is, I mean, a water jacket on the barrel of the cylinder. The only use that jacket water was at all was to cool the top of the cylinder so that the heat would not be transmitted down the walls of the cylinder and expand the gas entering the cylinder. We made a great number of experiments

along this particular line, and we did it, primarily, to find out how much water it was proper to run through the jacket. We wanted to be able to give our engineers and operators instructions as to the amount of water necessary. As our investigations proceeded it developed that jacket water was of no particular use, except to cool the discharge end of the cylinder so that the heat would not be transmitted down to the barrel. Of course we did not go into the theory of superheat, because we got in a practical way the information we desired. The theorists could follow and try to satisfy themselves as to how the results were obtained if they cared to.

In our experiments we put a loose rim or bottom on the jacket, so that we could move it up and down, making the jacket any depth we desired. We were thus enabled to determine the effect of cooling any portion of the compressor cylinder. Tests were thus made on the efficiency of the compressor at different water jacket levels, making run after run under the same conditions, so we could correct errors, after which we made a number of runs without water at all. We found that with a low suction pressure, say from atmospheric to 10 pounds, and the standard condensing pressure, 185 pounds, the water jacket could be used to advantage, for, without it, the heat generated by compressing the gas would heat the compressor to such an extent that the barrel would warm up for some distance below the level of the valve seat. By experimenting we found that the proper place for the water jacket was just under the swell of the cylinder, and that is the way we are making this type of compressor to-day.

The compressor which Mr. Friedmann refers to, the Ebling machine, is not constructed as I have described; that is, it is not built in accordance with what we believe to be the best practice, but is the same as was used at the Rochester test, with the exception that they have a cork insulation inside which keeps the water away from the walls of the cylinder. For this reason he cannot compare what we did at Rochester and what we did at York with what happened on the Ebling machine. That is where he gets the 45.025, etc., on the superheat. The cork insulation makes a new condition, for it reduces the surface affected by the water in the jacket, and it upsets the results made by the comparison of the data obtained from compressors where the jacket water comes in contact with the whole barrel of the cylinder. The cork insulation used on the Ebling compressors was pitched and made water-tight so no water could come in contact with the walls of the cylinder, except under the swell, as I have described.

Mr. Friedmann claims that a single-acting machine does not need a jacket as much as a double-acting. Now, I differ with him, for this reason: A single-acting machine discharges the gas through one end, the top, which is always hot, unless it is cooled by water. In a double-acting machine we have a suction and discharge valve in each head. The suction coming in through the valve chamber cools the surrounding metal, including the metal between the suction and discharge chambers. This necessarily cools the walls of the discharge chamber, consequently, in the absence of jacket water, the discharge valve chamber of a single-acting compressor will be hotter than the discharge valve chamber of a double-acting compressor, because there is nothing to cool this chamber on the single-acting compressor unless you use a water jacket. We experimented on both single-acting and double-acting machines, and we found that the thing to provide against was the heat from the discharge chamber raising the temperature of the walls of the cylinder below the level of the discharge valve seat. If this is accomplished it is much better to insulate the balance of the compressor than to use jacket water on it.

I have no desire to withhold any information the York Manufacturing Company may have on this subject, and had I been in possession of a copy of Mr. Friedmann's paper before I came to this meeting I would have brought the data he requests with me. As it is, I am only generalizing and giving you what comes to my mind as I stand here. We went into this water jacket question very thoroughly, for the reasons I have given.

As I said, we were making practical tests and did not go into the theoretical reasons as deeply as we might. For that reason I am not prepared to discuss the superheat theories we have had brought to our attention, except to point out where some of the theories advanced have not been sustained by the tests I have mentioned. It is my opinion that the failure of these theories is due to the fact that their authors are not in possession of all the conditions under which the compressors in question were operated.

President Friedmann.—I thank Mr. Shipley for giving us exactly what I have asked for. I said I would like to know the reason for the change in water jacket design, whether it was based on figures or tests. Mr. Shipley has said that his remarks are not always printed. He offered at one time to drink all the water in the water jackets. I do not know whether that was printed or not, but it was a very remarkable statement to me. However, I would like to ask Mr.

Shipley whether he will not have some of his engineers prepare this material for presentation at the next meeting. Give us a little more data.

Thomas Shipley.—I will be very much pleased to give you any information we have.

N. H. Hiller.—Did I understand Mr. Shipley to say that when they had the lowest back pressure they had the greatest amount of hot water?

President Friedmann.—Yes, that is correct.

Karl Vesterdahl.—I would like to ask Mr. Shipley if he knows what the temperature of the discharge gas would be if the jacket is left off altogether?

Thomas Shipley.—We have all that. The only trouble we had was when we would run at a low back pressure the temperature would get up, as I remember it, to somewhere around 325 degrees. I think it got to about 325 or 350 degrees at one time.

President Friedmann.—349 degrees, I think it was.

Thomas Shipley.—Somewhere about that. That temperature would burn the oil and make the valves stick. That would be the only trouble.

Karl Vesterdahl.—Of course we all know that in a steam engine with steam at high temperature, the lubrication is destroyed and the cylinder is likely to be cut. Is the case not the same in an ammonia compressor without a water jacket?

Thomas Shipley.—The residue from the lubricating oil would bake on the discharge valves when the gas temperature was high. This would cause the valves to stick and refuse to work properly.

President Friedmann.—In making those tests in York you made them for finding efficiency as well as horse-power, didn't you?

Thomas Shipley.—No, we made those tests for general information.

President Friedmann.—Did that include the establishment of horse-power per ton?

Thomas Shipley.—Of course we were taking data which enabled us to compute the horse-power per ton, but we were taking fifty or seventy-five other readings. No matter what special conditions we were operating under we got the complete data every time. The data are all there and the averaged results are at your disposal at any time.

No. 95

THE EVAPORATIVE CONDENSER.

By J. Beaumont Spencer, New York, N. Y.
(Non-Member of the Society.)

The process of cooling a body by evaporating from its surface a volatile liquid has been made use of in all eras and among the savages in all parts of the world. In tropical countries drinking water has been kept cool by moistening the surface of the bag or vessel containing it and hanging it in an air current. The evaporation from the surface produces a cooling effect that reduces the temperature of the water many degrees below that of the surrounding atmosphere. With an atmospheric temperature of 100 degrees Fahr., water in such a vessel may be maintained at 80 degrees or even less, depending upon the degree of saturation of the outside air. It is the utilization of this ancient method that is applied to condensing of steam at high vacuum or of ammonia at low head pressure in what is known as the evaporative condenser.

At first thought it seems rather remarkable that with condensing water at 90 or 100 degrees Fahr. and air blast at 100 degrees it would be possible to condense a pound of steam under a 28-inch vacuum, and employ less than a pound of water in the process, or to condense ammonia with not more than two and one-half gallons of water per hour per ton of refrigeration per day and maintain a head pressure not exceeding 180 pounds gauge. Nevertheless, all these things are possible, and have been done in a number of installations.

The purpose of this paper is to describe the process and explain the possibilities of this method of evaporative condensing as compared with the present system of condensers and cooling towers employed where the amount of circulating water is limited. Since this question is a new one in the field of refrigerating engineering, an explanation of test reports would involve a larger amount of detail than it is proper to introduce in a paper of this character. The points to be brought out are the general summary of possibilities and explanation of the "hows and whys."

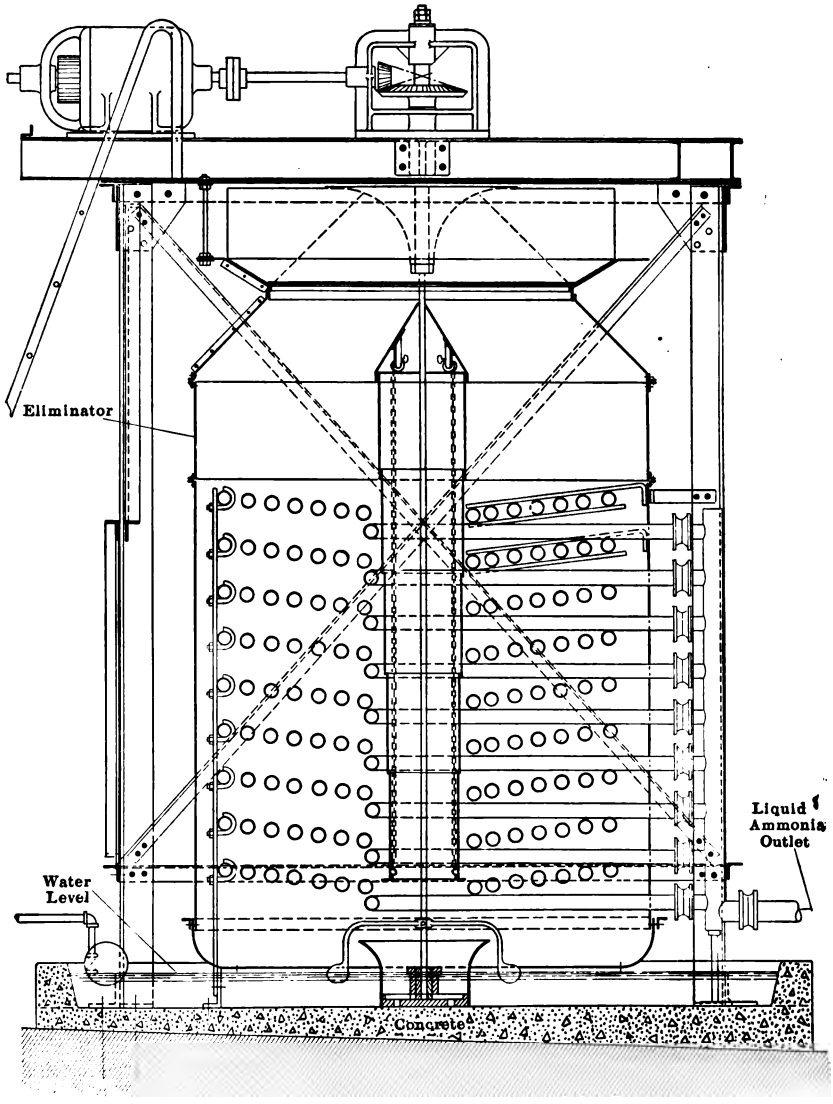
The first questions an engineer considering this method of condensing will ask are: Granting that the method is theoretically possible, what of its commercial feasibility? What is it going to cost to condense steam or ammonia or do other work of condensing or cooling by this method? What kind of an apparatus can be designed to produce the result in a practicable manner? The answer to these questions is that the process is a commercially practical one.

Having ascertained that the evaporative condenser is a commercial proposition, and hence warrants your attention from other than scientific viewpoint, it is necessary to go back again to the discussion of the principles involved, to determine the best methods of applying them for commercial purposes. The problems involved in ammonia and in steam condensing are primarily the same, but the method of solving them are radically different.

In the operation of the Griscom-Spencer evaporative ammonia condenser the incoming air is first saturated, thereby being reduced to the dew point corresponding to the weather condition. This air is then raised in temperature along the saturation curve and the outlet temperature determines the exact quantity of water which has been vaporized for a given entrance condition. This condenser is designed for counter-current action so that its outlet temperature will closely approximate that corresponding to the head pressure carried. This condenser accomplishes its purpose at a minimum cost of operation and maintenance, and with a maximum efficiency of heat transmission through the coil surface. The apparatus consists of one or more helical coils fastened at the ends to a vapor and liquid header. These coils are enclosed in a cylindrical, sheet iron casing, through which an air current is induced by a fan at one end, the other end being suspended close to the surface of a water tank. At the bottom of the casing, and concentric with it, is a deflector, the purpose of which will be made clear later. At the top, immediately before the air enters the fan, an eliminator is placed which prevents the discharge of any entrained moisture. The water level in the tank is maintined constant by a float feed control.

METHOD OF OPERATION.

In detail, the operation of the unit is as follows: Hot compressed ammonia gas enters the upper header, passes through the coils where the latent heat is abstracted and liquefaction occurs, and this liquid then flows by gravity through the header to the ammonia receiver. This air action is somewhat more complex. Due to the suc-



AN EVAPORATIVE AMMONIA CONDENSER

tion created by the fan, an air current flows under the lower edge of the casing at high velocity. This causes the mechanical entrainment of a considerable amount of water, which is immediately dashed against the sides of the deflector and broken into a fine spray. Due to the intimate contact of the entering air with the water, it is in a saturated condition when enering the bottom of the casing, and has, therefore, a slightly reduced temperature. It also contains a large amount of water in suspension. During its passage through the shell this mechanically suspended water wets the coil surfaces. These surfaces are at a high temperature, due to, and varying with, the head pressure carried and consequently heat the passing air. This rise in temperature of the air increases its capacity for absorbing moisture, and the water deposited on the coils undergoes rapid evaporation. This takes place at practically atmospheric pressure, and therefore the heat abstracted by every pound of water evaporated from the coil surface is approximately 1000 B. t. u., which heat must, of course, come from the compressed ammonia gas. The successful design of this machine, therefore, depends upon the coordination of the factors of coil surface, amount and velocity of air, and humidity of the outside air.

Since the heat to be removed is an easily determined quantity, dependent upon the head pressure, it is desirable to carry in the machine the quantity of air necessary to effect this removal, and this quantity can be readily pre-determined for any given atmospheric condition. If this atmospheric condition is assumed as the worst possible or the worst average for a given locality, the resultant machine can be guaranteed to operate at a given head pressure which will never be exceeded, provided, of course, the assumption regarding the average atmospheric conditions is correct.

The operating charges in connection with this condenser are for make-up water and for electric current or other power to drive the fan. This make-up water will not exceed two and a half gallons per hour per ton of refrigeration per day. The power necessary to operate the fan in the vicinity of New York City would approximate one-eighth horse-power per ton of refrigeration.

The evaporative condenser combines in one operation the function of surface condenser and cooling tower. Refrigerating plants have their peak load in the summer time, and at that time also the efficiency of the cooling tower is at its lowest. The minimum outlet temperature of the tower water will always be a few degrees above the temperature corresponding to the dew point. This water is

then passed counter-current-wise through ammonia condensers and the minimum outlet temperature determines the head pressure. The average temperature of the cooling medium is therefore many degrees above the dew point. The evaporative ammonia condenser overcomes this feature under all weather conditions, in that the average temperature of the cooling medium is at least as low as the temperature of the circulating water leaving the cooling tower. In other words, the use of the evaporative feature maintains an effective temperature on the condensing coils considerably below that of the best cooling tower combination possible. These condensers are now built in units varying from ½ to 200 tons of refrigeration per day.

APPLICATION TO STEAM CONDENSING.

In considering the practical application of the evaporative condenser method, its relation to the stationary steam engineering field is quite as important as it is to the refrigerating and cold storage industry. On the Thompson evaporative condenser the cooling action is again entirely dependent upon the capacity of the air to absorb moisture, as it continually increases in temperature. The steam condenser, however, operates on a different principle, as the entering air is not saturated, due to intimate contact with water before passing over the tube surfaces, which in this case are maintained in a wetted condition by mechanical sprays. A draught is induced by fans located above the apparatus so that the air enters at the bottom. In the steam condenser the air velocity need not be as great as in the ammonia condenser, since it does not have to carry moisture in mechanical suspension; in fact, it should not be allowed to carry any moisture. The air entering the condenser has the same humidity and temperature as the outside air. However, as it passes over the tube banks it increases in temperature, and hence has an increasing absorption capacity. In designing this unit the features to be considered are quite similar to those of the ammonia condenser.

The Thompson evaporative condenser has been in successful operation for the past six years. In one instance a unit condensing 11,000 pounds of steam per hour at from 26 to 28 inches vacuum has been in continuous service for this period, and during this time has only cost $28 for repairs. At the present time two units, one of 6,000 pounds at 26 inches vacuum and one of 13,000 pounds at 28 inches vacuum, are being erected in the vicinity of New York City.

DISCUSSION.

N. H. Hiller.—What is the mechanical construction of these evaporative condensers?

J. Beaumont Spencer.—To date there have been two kinds of steam condensers constructed and built at three points in the West. At the works of the American Brass Company, of Kenosha, Wis., J. M. Thompson made an installation of two condensers in 1905, guaranteed to draw 24 inches of vacuum. He succeeded in drawing 27 inches. The steam was brought into these condensers, which consist of a cylindrical shell, which looks very much like an ordinary return tubular boiler, only the tubes used are 1-inch brass. The steam was brought into the shell and a spray of water was caused to enter the tubes, sucked in by a draft of air from a fan, which was discharged to the roof. Lake water was used and up to about a foot and a half from the entrance there was a deposit of fine dust. There was never any scale precipitation such as we have in boilers. That is, of course, what would be expected, because the water is introduced in a fine spray, which evaporates, leaving a fine dust, which represents the impurities in the water. This dust, however, does not accumulate in any quantity. The steam coming in surrounds the tubes and is condensed by the water evaporating all along this surface. Two of those condensers were installed in 1905 and they have been operating up to the present time with a remarkably low expense for up-keep. I got the information directly from the superintendent of the plant and also in a letter from the manager, in which he states that they have spent only $13.00 to keep these condensers in condition since they were installed. This does not include, of course, the pump up-keep.

The water that is drawn in may be lake water or it may be the water of condensation, as in the case of one of these condensers installed in the Western Cold Storage Co. plant, Chicago, where they have two of these condensers running on the exhaust from the engines driving the ammonia compressors. There they use water from the hot well, and I have seen these condensers drawing 29 inches of vacuum at the engine, which is pretty good for that elevation. At the time they were running under a full load. The guarantee was to draw from 25 to 26 inches vacuum.

The condenser I have just described is the first that I have any record of. The next development was to reverse the air and steam and make of it a steam tube condenser. One of these condensers

was installed at Kenosha a year after the two others were put in. In the second type of condenser the steam comes in at the top, the condensation goes out at the bottom to a wet vacuum pump, and the air goes out to a dry pump after having been sucked through perforated pipes, which distribute the air in a more efficient manner than could be done if it were taken directly out of the top. The tubes, which run across in banks, three rows to a bank and about four banks altogether, terminate in a rectangular header. Through the center runs a shaft on which a fan is carried. The space around the tubes is encased in a sheet iron covering of about No. 13 gauge. The heads are not tied together by any means except by the tubes. The result is that there can be no expansion strains on the headers, since one end is perfectly free to move and the sheet iron is fastened on so as not to make any resistance to movement. That is probably the reason why in this case they have so little trouble in keeping the tubes tight.

Under this is a tray which is kept partly full of water, and from this we suck the water up through a pump and deliver it at about twenty pounds pressure into this hollow vertical shaft, which is supported on thrust bearings. The shaft is driven at the side by bevel gears. The water is introduced at the top of the fan shaft, passes down through the hollow shaft and out through a number of rotating arms on which the spray heads are placed. Now the manipulation of those sprays and the rate at which the tubes are wetted was the result of considerable experimenting, so as not to get the tubes flooded. If you get excessive flooding insulation results and you get your water heated up above the temperature of the wet bulb. In this type of condenser the air is simply drawn through a mass of tubes and discharged. That is the principal construction in use at the present time.

There have been other experiments made, the results of which will lead to another design of condenser that will be very different from this in principle, operating similarly to the double pipe ammonia condenser. In this type the steam entering at the bottom or at the top—both ways were tried—passes up or down through a tube in which there are spiral baffle plates, the air being drawn up while the spray is being allowed to run down around another spiral or helical baffle, thus getting a whirling action, which seemed to increase the efficiency per square foot of surface by about fifty per cent.

In the ammonia condenser, of which Harry Benz is patentee, we have a tank of water in the bottom and a casing of peculiar

construction sloping in a little at the bottom so as to direct the current of air that is being drawn in by the fan. The air is sucked down across this surface of water and then, in the bottom of this chamber, encounters baffles particularly designed to give a finely divided spray of water to produce the results I have mentioned in the paper; namely, first reducing the air to the temperature of the dew point, or rather, of the wet bulb, since in the ammonia condenser we have to maintain a low temperature throughout. The air is then discharged by the fan at the top. In the steam condenser it is not necessary to keep the temperature down very low. For instance, you take the air in at 100 degrees. You must not let any of that 100 degree air strike these three ammonia coils. Whether this is the best arrangement or not I do not know, but by means of the spray we chill the air immediately. The ebullition in the bottom is of sufficient violence to maintain the spray in the chamber, to keep the temperature down to the dew point.

Louis Block.—The fan draws the water into the air?

J. Beaumont Spencer.—No, if the fan works right there is no water going out except in the form of moisture.

Louis Block.—The fan moves the water?

J. Beaumont Spencer.—The fan moves the water only by reason of the velocity of the air. The air is drawn down through the chamber at a velocity of about 1,500 feet per minute. The result of the air changing its direction as it impinges on the surface of the water produces entrainment. This apparatus is the result of a great deal of experimenting, because it is not an easy matter to secure the right amount of entrainment. This apparatus has been used also in air washers. Mr. Benz originally secured his idea from the design of an air washer. The only power required is to give the air its velocity. We deliver the air at so many inches pressure. As a matter of fact, it takes about one-eighth of an ounce of effective pressure, the sum of the two heads, velocity and static. The fan as it is normally rated, has to deliver the necessary number of cubic feet of air at about one-eighth of an ounce pressure.

Louis Block.—Did you ever determine the power necessary to move the fan?

J. Beaumont Spencer.—Yes, sir.

Louis Block.—Per unit of refrigeration?

J. Beaumont Spencer.—Per unit of refrigeration; yes.

Louis Block.—And what is it?

J. Beaumont Spencer.—Well, I haven't the exact data with me. I was not going into those points in this paper, but I can tell you after a moment's figuring. For 30 tons the fan requires about 5 horse-power, or 1 horse-power for every six tons of refrigeration. Now, of course, you understand that it is not necessary to run the fan so fast in the winter time as in the summer time. These condensers are designed for maximum summer conditions, and then we cut down the speed of the fan as the weather gets cooler.

R. E. Bridgette.—What metal are those ammonia condensers made of?

J. Beaumont Spencer.—Ordinary steel or iron tubes.

R. E. Bridgette.—How many years have you had any of these coils in operation with air loaded with vapor blowing over them?

J. Beaumont Spencer.—The two installations I have a memorandum of are those of the Rotary Photogravure Company in Newark, installed in 1909, and still running, and the Mechanical Engineering Company, in Philadelphia.

R. E. Bridgette.—Mr. Spencer, before you manufacture and sell a great many of those I think it would be a good idea to go and examine one of the tubes very carefully, because I believe the tubes, with the damp air blowing over them, will deteriorate very rapidly.

J. Beaumont Spencer.—I think that is very true.

L. Howard Jenks.—What becomes of the residuum from the water that is evaporated? As I understand, the condensation of the ammonia depends on the heat of vaporization of the amount of water evaporated.

J. Beaumont Spencer.—Yes.

L. Howard Jenks.—Therefore the water is practically all vaporized and the residuum would be left on the coils. How is this taken care of in practice?

J. Beaumont Spencer.—In the case of Mr. Thompson's condenser installed at Kenosha, Wis., they were using lake water. They got this first type of condenser, in which the air goes through the tubes. There was a slight precipitation in the form of dust covering the first foot or foot and a half in each tube when dried. Throughout the rest of the tubes there was nothing. In the case of the other type of condenser, where the steam is in the tubes and water surrounding them, there was no precipitation or scale at all. The reason for that would appear to be that as the scale is precipitated it is washed off. It forms in very fine particles and the temperature is not such as would cause it to bake. In the former case you get a very finely

divided spray that evaporates and deposits the dust, but there is a blast of air going through which simply carries the dust right through. That is the result in practice. These condensers have been running, as I say, for six years in one case and five in the other.

L. Howard Jenks.—Do you get any of this dust in the exhaust pipe from the fan, in the type you have described?

J. Beaumont Spencer.—No, there is nothing apparent. The amount would be small, as you can see when you figure that you are blowing perhaps 30,000 cubic feet of air per minute through a condenser that is only evaporating 15,000 pounds of water per hour and carrying only about 50 grains of solids per gallon. The amount of dust that would be left by the evaporation of the water would not be appreciable. You couldn't find it.

Charles H. Herter.—The evaporative condenser will undoubtedly meet with favor wherever cool water is not available, but I would not use it as a steam condenser, unless water is scarce, because water at any temperature will do for condensing steam in an ice plant and the power for the fan can be saved. Those who are not ready to discard their atmospheric condensers could probably secure some of the advantages of the evaporative condenser by directing a fan blast on to them in summer. While the air velocity would not be high it could be made to answer the purpose.

To condense ammonia in the most economical manner condensation should be effected in three stages: first, a vapor cooler to take out the superheat, for this water at ordinary temperature can be used without fan; second, the condensing section proper to liquefy the gas (this can be of the evaporative type); and, third, a liquid cooler to cool the liquid down as near 32 degrees Fahr. as possible. This part might again be of the evaporative type and provided with a separate supply of cold water. The heat to be extracted in these three stages is about 20 per cent., 100 per cent. and 10 per cent., respectively; total, 130 per cent. Providing the liquid cooler with ample surface is probably cheaper than operating a fan. To what extent forced draft will accelerate oxidization of the iron surfaces continued use only will tell.

J. Beaumont Spencer.—I agree heartily with what Mr. Herter says. The use of an evaporative condenser to supplant the ordinary form of condenser would never come up, because you would not have to put in a cooling tower if you get plenty of water. You might consider the advisability of putting in a tower in the summer when your water was a little bit too warm to suit you. That is

just exactly what you suggested. In the summer you would provide for a means to use your present condensers and blow a draft of air across them. That is first class if you can do it, but it is difficult to arrange your present installation to make use of that.

Charles H. Herter.—Would this method be permissible? Are there any patent rights prohibiting it?

J. Beaumont Spencer.—No, there is no patent right covering water cooling by evaporation. The patents of Mr. Benz and Mr. Thompson cover the application to particular forms of condenser.

I won't go any further into the principle of evaporative condensers unless you have other questions to ask; but the thing has been done in actual practice, and the power required will be about one-third of that required by the ordinary condenser and cooling tower. The head pressures may be kept down quite low on the ammonia side and the vacuum maintained quite high in steam side.

No. 96

FRUIT PRECOOLING PROBLEMS.

By A. V. Stubenrauch, Washington, D. C.

(Non-Member of the Society.)

I am very glad to have this opportunity of appearing before this Society, although I feel that the paper which I have prepared may not prove of as great interest to you as the discussion of some more technical features of refrigeration.

Several years ago my good friend and predecessor, G. Harold Powell, pointed out to the members of this Society some of the more important problems dealing with the transportation of fruit products in sound condition from the points of production to distant markets. It is a remarkable fact that many of the regions specially adapted to the production of high-class fruits are located at relatively great distances from the most important centers of consumption. Not very many years ago the distribution of perishable fruits was limited to markets adjacent to the orchards; and were it not for the fact that many of the difficulties encountered in transporting fruits over long distances have been overcome, the tremendous development of the fruit-growing industries of to-day would have been impossible. The development of transportation and storage facilities is the foundation upon which rests the success of the diverse fruit-growing industries of this country and of the whole world. Without means of safely transporting fruits it would be impracticable to supply distant markets. Without efficient storage facilities it would be impossible to lengthen the market season of various fruit crops so that the large quantities now produced could be distributed throughout the year. It would be a case of "feast or famine" so far as most fruits are concerned.

With the development of our fruit industries, as was pointed out by Mr. Powell, problems in the handling, transportation and storage of these products have arisen, and it has been the function of the Office of Field Investigations in Pomology, of the Bureau of Plant Industry, to undertake the investigation of these various problems. During the past nine or ten years considerable headway has been made in many of these lines. It is not my purpose to review

at any great length the results of the Bureau work, as no doubt most of the members of the Society are familiar with the publications which have been issued by it from time to time.

One of the main features of the fruit transportation and storage work has been the investigation of problems dealing with the prompt and rapid refrigeration of fruits. The first work along this line was done by Mr. Powell, in 1904, when he demonstrated the practicability of shipping Georgia peaches in sound condition after prompt and thorough cooling before loading into the cars.

To this system of promptly and quickly reducing the temperature of fruits intended for shipment the term "precooling" has been applied and is now in general use. Since the beginning of the precooling work by Mr. Powell, the investigators of the Bureau have studied many features of the problem. The work is far from complete, as some of the problems pertaining to the rapid cooling of produce remain unsolved. It is only with the assistance of technical engineers working along lines similar to ours, and taking into consideration the results of the Bureau work along these lines, that the problems will eventually be worked out.

LIMITATIONS OF PRECOOLING.

When the precooling of fruits was first suggested, it was at once seized upon as a means of overcoming practically all of the difficulties which had thus far been encountered in the handling and shipping of fruits. The orange growers of California saw in this process a remedy for their decay troubles; the deciduous fruit growers of California and the Southern States immediately considered precooling an important factor in shipping their fruit crops to market; the fruit growers of the more recently developed Northwest fruit districts were firmly convinced that only after precooling could their crops be transported in sound condition. The interest in the subject was by no means confined to the producer and shipper. Transportation lines became interested and saw in this new system of handling fruits remedies for many of the troubles which confronted them. In a measure, precooling became something of a fad among the handlers, shippers and transportation lines interested in the movement of fruits.

It has been the policy of the Bureau workers consistently to advise conservative caution in the commercial application of precooling. This cautionary advice has been given to the producers and shippers and to transportation companies. Perhaps, to some

extent, this is one of the reasons why the application of precooling to the handling and shipment of fruits has not become more extensive. However, a number of plants designed for the precooling of fruits both before loading into the cars and after loading have been erected and are now in operation.

It is entirely foreign to the discussion which will be made in this paper to consider the various types of plants which have been erected. Suffice it to say, that the ideal type of plant suitable for all conditions and all kinds of fruit has not yet been found. We are not at all certain that it is safe to recommend any special type of plant for all cases. Under some conditions the plant intended only to precool fruits before they are loaded is most advantageous, while, undoubtedly, under other conditions, car precooling after loading is preferable.

EXPERIMENTAL PRECOOLING PLANTS.

The precooling investigations of the Bureau of Plant Industry have been conducted on as systematic a plan of operation as it has been possible to devise under commercial conditions. The first work done by Mr. Powell was performed with rather crude equipment, consisting of two ordinary refrigerator cars, using ice and salt as a refrigerant and stacking the fruit openly, one-half carload in each car. The later work of the Bureau on oranges was carried on in connection with a commercial cold storage plant, and some considerable progress was made in the work with this equipment. However, it was found that, owing to the commercial demands of the plant, the exact conditions desirable for carrying on the Bureau investigation were impracticable without special experimental equipment. In order to make it possible to conduct precooling investigations at any point, the Bureau equipment, consisting of a portable refrigerating plant installed in a freight car, was devised by S. J. Dennis, a refrigerating engineer, who has been a member of the Bureau staff of investigators for the past five years, and much of the progress of the Bureau work along these lines is due to his efforts.

Most of the precooling investigations for the past four years have been carried on by means of the portable experimental plant. It is unnecessary to give a description of the plant, because full descriptions have been published at various times. With a fully equipped plant it has been possible to carry on the work

under very satisfactory conditions, and special pains have been taken to obtain comprehensive data on all phases of the problem.

In order to utilize the Bureau equipment for obtaining comparative data on both car and warehouse precooling, at points where no suitable insulated room is available, a refrigerator car was made to serve as a "warehouse" by equipping it temporarily with perforated false floor and ceiling and placing a tight partition across the car at each end of the load space. The space under this false floor communicated with the ice bunker at one end, while the space above the false ceiling communicated with the ice bunker at the other end. The cold-air circulating pipes of the portable refrigerating plant were coupled to the ice hatches of this car at each end, the same as for regular car precooling; but when the blast from the plant was circulated, the effect of the false floor and ceiling and the partitions was to cause the cold air to pass vertically through the load of fruit by a comparatively short path, the perforated floor and ceiling distributing the air current quite uniformly over the entire car. The cold air blast delivered by the plant being reversible in direction, the air could be forced either upward or downward through the load of fruit. Notwithstanding the short distance traversed by the air in passing vertically through the load, a reversal of the air current during precooling was found to be necessary in order to avoid too great inequality of cooling at the top and bottom.

An ordinary carload of fruit was readily precooled in this car, the packages being stacked in open order to allow free air circulation. The fruit was piled somewhat higher than in a regular carload. After precooling, the "warehouse" car was set alongside an empty iced refrigerator car on an adjacent track, and the cooled fruit transferred for shipment. To avoid exposure of the cold fruit to warm, moist air during the transfer, a folding canvas hood or bellows vestibule, mounted on the side of the "warehouse" car, was extended against the iced car, forming a closed passageway between the cars. An extremely simple and satisfactory type of vestibule was developed for this purpose.

While the fruit temperatures in this warehouse car were not as uniform as was anticipated, in general they compare well with those obtained in experiments in a small warehouse precooling plant which was similarly equipped with a false floor, through the perforations of which the cold air was distributed over the room; and it is believed that the conditions in the experiments with this car, as

regards air distribution and equality of cooling, represent very nearly those that would have obtained in an actual warehouse room.

As the equipment owned by the Bureau is expensive, and as it is possible to work at only one point at a time, during the past spring and summer an experimental plant using ice and salt as a refrigerant, designed by Mr. Dennis, was erected at Salem, Ore., by the Salem Fruit Union, and turned over to the Bureau for experimental work. Several other similar experimental plants are proposed, and during the coming season it is probable that operations will be carried on at another point in Oregon and in Georgia.

As it will be of some interest to the members of the Society, I will give a brief description of the ice and salt experimental plant in use at Salem and proposed at other places. The item of expense had to be considered in the erection of these plants and, consequently, they were planned to be only of a temporary character. The insulation used is eight to twelve inches of mill shavings. The refrigeration is obtained from ice and salt, and the cooling is performed by drawing air directly through tanks containing crushed ice and salt, and then forcing it through ducts beneath a false floor in which holes are bored. The cold air rises through the holes, circulating through the precooling room, and by means of overhead ducts is conducted back through the ice tanks to the fan to be again circulated. The construction of the tanks is of a magazine type, devised by Mr. Dennis. The tanks are 6 feet deep, 24 inches thick and 7 feet long, and in the Salem plant, designed to cool one carload of fruit, four of these tanks, holding about five tons of ice and working in parallel, were used.

To determine how much work could be done, and to obtain data on which to base the design of a working plant, a small experimental plant was equipped at the experimental farm of the Department at Arlington, Va. This plant comprised an upright wooden tank about two feet square and six feet high, intersected at the bottom by a horizontal air box or duct, one foot square. Wire gratings placed across the openings, where the air duct connected to the tank on either side, prevented the ice and salt in the tanks from entering the ducts. The tank was filled with crushed ice and salt, and air forced through the duct by a blower, passing across the bottom of the tank through the ice and salt mixture. As the ice was melted out at the bottom by the air current it settled in the tank, the upper portion of the tank forming a magazine or reservoir, feeding

the ice and salt mixture by gravitation to the lower end of the tank, where practically all the meltage occurred.

A series of experiments was made with this outfit, with different percentages of salt mixed with the ice, and with varying air volumes. Air temperatures, pressures and velocities, rates of meltage, and temperatures and specific gravity of the drip were carefully determined. The amount of work which this small apparatus was capable of performing was rather surprising. Over 400 cubic feet of air per minute was cooled from between 50 and 60 degrees down to 2 or 3 degrees Fahr., in passing through two feet of crushed ice, with not over 20 per cent of salt; and this rate was maintained continuously and quite steadily until the top of ice in the tank had sunk below the top of the air gratings. An air pressure of less than two inches head of water was required to force this amount of air through the two feet of crushed ice. The temperature of the air delivered was determined almost entirely by the amount of salt mixed with the ice, and was only slightly affected by the rate at which the air was forced through the ice, up to the limits of the blower used.

This magazine type of tank, as applied to direct refrigeration of air by a freezing mixture, is believed to be new. It was designed by Mr. Dennis, and the experiments with it were carried out by him. The simplicity, effectiveness and compactness of the apparatus suggest its adaptability particularly to installations of small size, of a temporary character, or in general where low first cost is a prime consideration. It was developed in response to the need for a simple and inexpensive system of refrigeration for use in experimental fruit precooling.

RESULTS OF TESTS.

In precooling cherries and fresh prunes at the Salem plant it was found unnecessary to operate the fan continuously. Five per cent salt was used, and this mixture gave air temperatures from 26 degrees to 28 degrees Fahr., with an estimated volume of air of about 2,500 cubic feet per minute.

The precooling work of the Bureau has now gone far enough to indicate its probable ultimate value in the handling and transportation of fruits. It is remarkable that the early assumptions regarding the uses of precooling have been borne out by the results of careful investigation. It has been emphasized from the start that precooling should never be used as a means to overcome losses or

deterioration resulting from improper methods of handling in preparing the fruits for shipment.

Some of the earlier work with oranges has been presented to the Society, and, doubtless, most of the members are familiar with this investigation. The work during the past three years has been extended to the table grape of California, the Georgia peach and to cherry and fresh prune shipments from Oregon, and red raspberry shipments from the State of Washington. In all of these investigations the importance of the method of handling the fruits in preparing them for market has been emphasized. There has been no exception to the general principle worked out with citrus fruits. The experiments carried on with some of the more highly perishable fruits indicate that precooling cannot be depended upon effectively to replace methods of handling which insure the packing of fruits in sound condition. The results obtained during three seasons of work on California grapes, Table I, show that precooling produced no material reduction in decay during transit following rough handling. As the results of all three seasons are consistent, we feel certain that this conclusion is correct.

TABLE I.

PERCENTAGES OF DECAY IN PRECOOLED AND NON-PRECOOLED SHIPMENTS OF COMMERCIALLY HANDLED TOKAY GRAPES FROM LODI, CAL., TO NEW YORK.

	On Arrival.	Two Days Later.	Four Days Later.
Season 1909.			
Precooled	6.6%	12.7%	16.8%
Non-precooled	7.5%	10.9%	15.1%
Season 1910.			
Precooled	7.5%	11.1%	15.1%
Non-precooled	8.7%	12.2%	17.5%
Season 1911.			
Precooled	6.5%	12.2%	16.7%
Non-precooled	8.1%	12.8%	17.0%

The diagrams, Figs. 1 and 2, show the placing of the thermometers to obtain temperature records in the cars, and the tables give some of the temperature records obtained. It is very difficult to place thermometers in packages of fruit loaded in a car or in a warehouse room to give a fair average of the temperature conditions in the load as a whole. After fruit is loaded in the cars it is impossible, with ordinary thermometers, to obtain the temperature

of the fruit at the bottom except near the car doors or between the braces of the load. Most of the records obtained, therefore, are from the top tier, or in the boxes, or crates, most exposed to the cold draft, where fruit is precooled after loading.

In a study of precooling it is necessary to consider the actual temperatures of the fruit. Careful investigation shows that merely exposing packages of fruit to a blast of cold air for some time is not sufficient to cool the contents of the package. The temperature records obtained in the Bureau work have been designed to show the fruit temperatures and, in order to learn the rapidity with which the entire contents of a package of fruit may be cooled, thermometers near the outside of the box, or crate, are inserted and long thermometers, reaching to the centers of the same boxes, or crates, are also used. We were not at all surprised when it was found that the temperature differences in the same box of oranges frequently reached from 10 to 18 degrees Fahr. after the precooling process had continued for some length of time. The insulating effects of the paper and the tightness with which the fruit is packed in the boxes were realized to be effective barriers against the circulation of air through the package.

When the work on grapes in four-basket crates was begun it was thought that this more open package would allow of some air circulation through the crate, and, consequently, should result in greatly reducing the time necessary to cool the entire mass of fruit. While it was found that the crate package resulted in more rapid cooling, there was still a great difference of temperature between the outer and the interior portions of the crate. Frequently temperature differences of 15 degrees were found in the same crate of grapes. These figures are shown in the accompanying Tables II, III, IV and V.

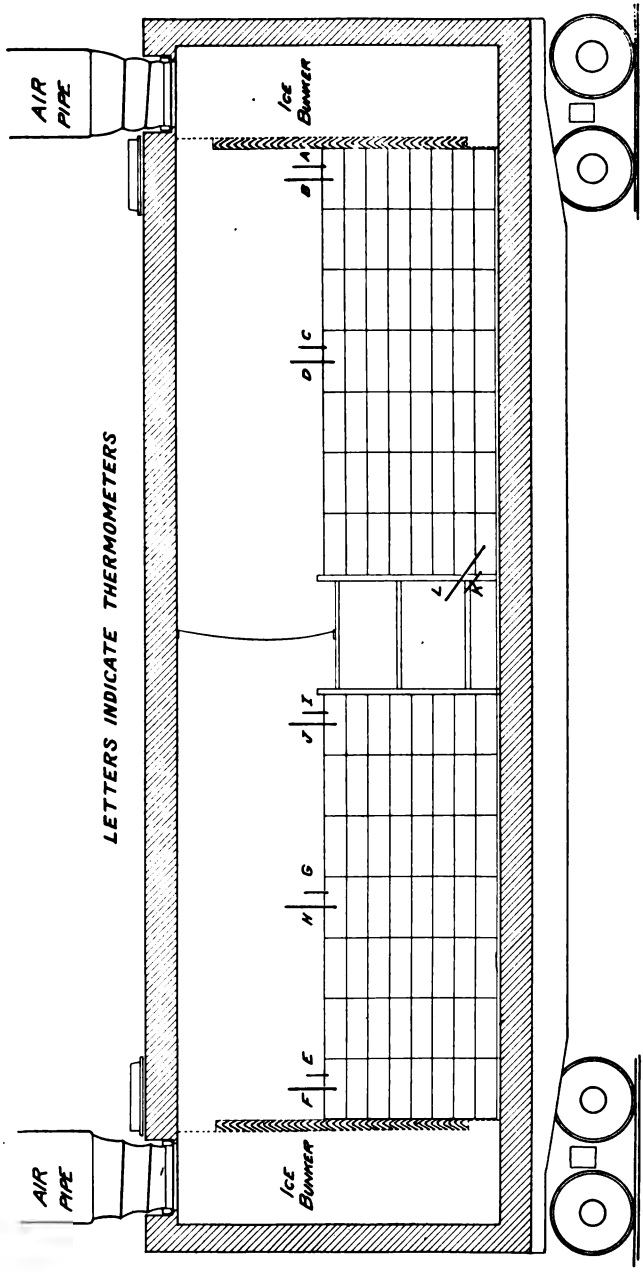


FIG. 1.—STANDARD CONSTRUCTION OF REFRIGERATOR CAR

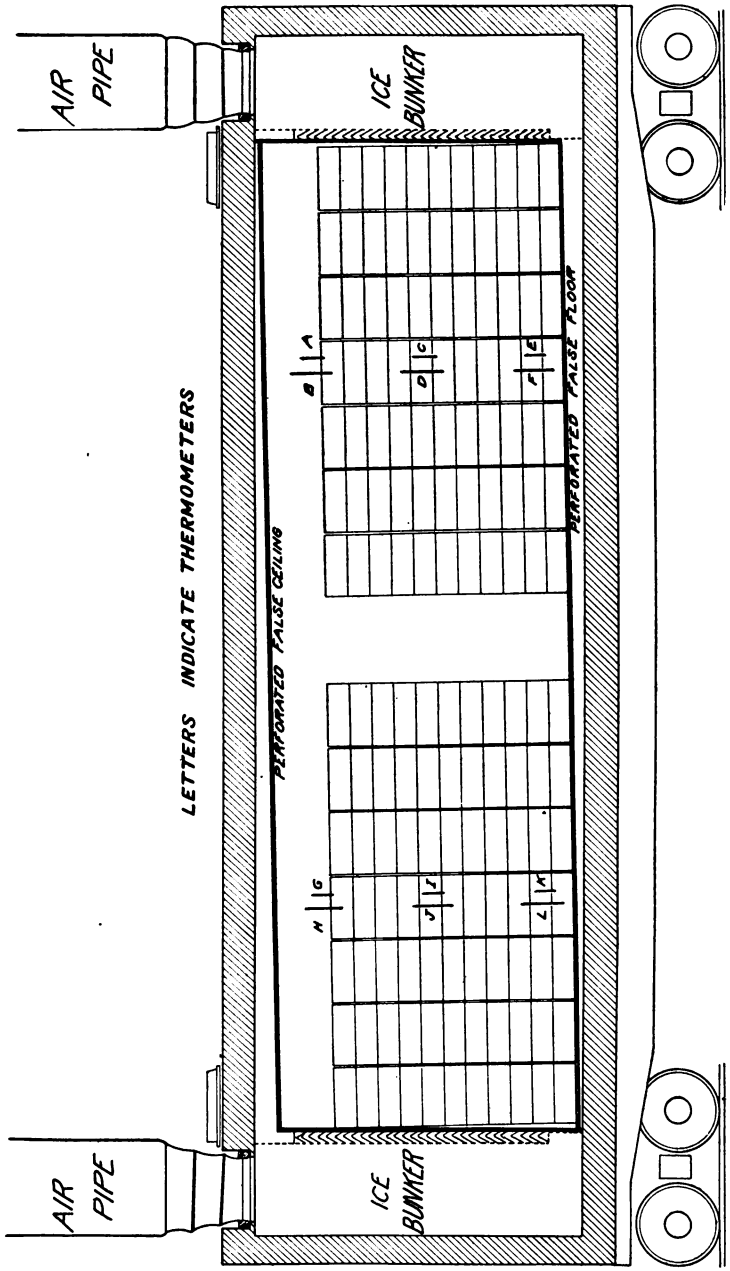


FIG. 2.—SUGGESTED CONSTRUCTION FOR REFRIGERATION CAR. REFERRED TO AS "WAREHOUSE CAR"

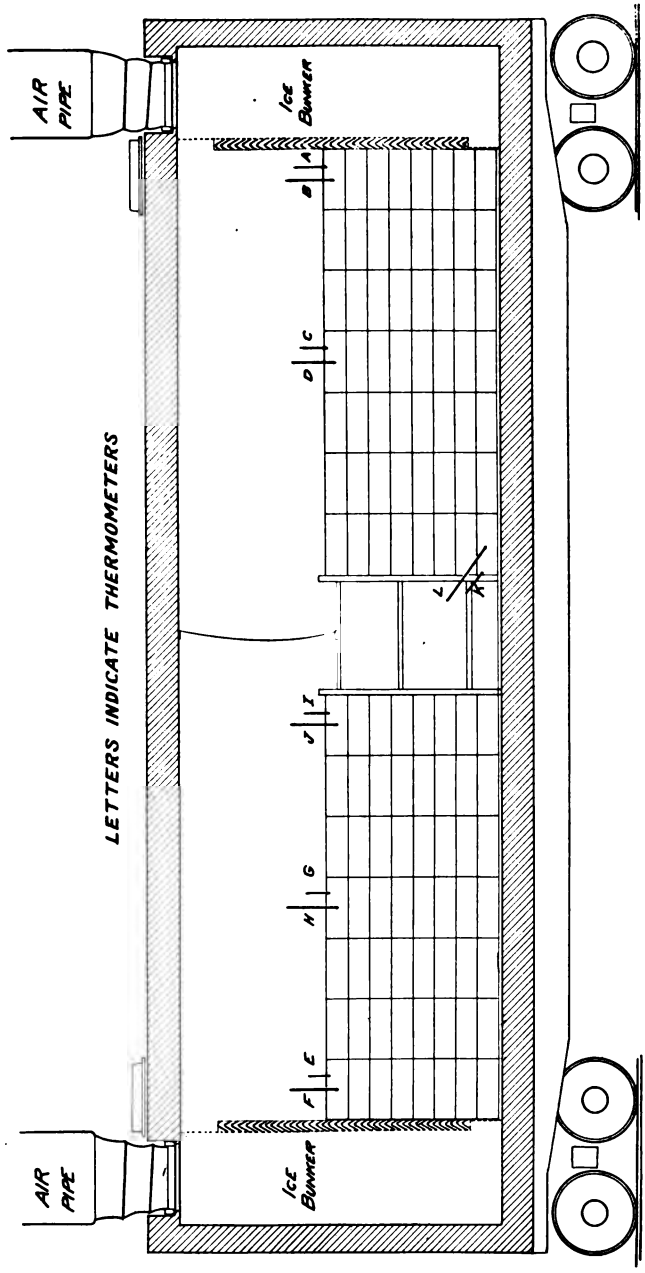


FIG. 1.—STANDARD CONSTRUCTION OF REFRIGERATOR CAR

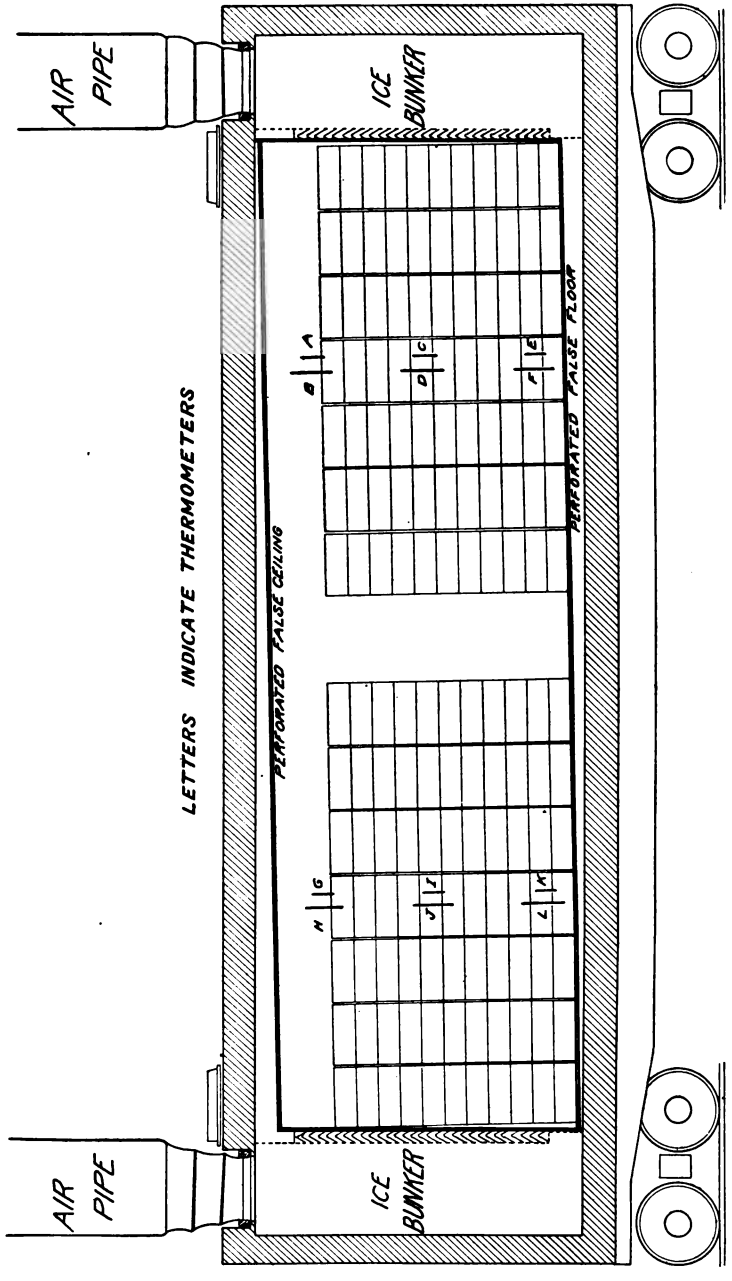


FIG. 2.—SUGGESTED CONSTRUCTION FOR REFRIGERATION CAR. REFERRED TO AS "WAREHOUSE CAR"

TABLE II.

TOKAY GRAPE PRECOOLING IN CAR. PORTABLE REFRIGERATING PLANT, LODI, CAL., OCTOBER 2–3, 1911.

AVERAGE TEMPERATURE OF FRUIT, DEGREES FAHR.

Time.		Grand Average.	South End of Car.	North End of Car.	Center of Car.	Center of Package.	Outer Fruit Layer.	Temp. Diff. in Package.
Hr.	Min.							
0	0	59.7	58.6	58.6	62.0	58.8	60.5	1.7
3	55	47.9	48.2	48.4	47.0	53.8	41.9	11.9
5	55	42.8	43.0	45.0	40.5	49.9	35.8	14.1
6	48	37.0	37.3	40.1	33.6	44.6	29.4	15.2
18	40*	44.3	45.0	46.7	41.2	42.2	46.3	4.1

Average temperature of air to car		25.6	degrees Fahr.
Average temperature of air from car		39.1	degrees Fahr.
Average temperature difference		13.5	degrees Fahr.
Net time of air circulation		6.27	hours.
	Max.	Min.	
Temperature of air to car	39.4	13.9	degrees Fahr.
Temperature of air from car	52.9	30.0	degrees Fahr.
Average temperature drop of fruit, total		22.7	degrees Fahr.
Average temperature drop per hour		3.62	degrees Fahr.
Approximate volume of air used, per minute		5400	cubic feet.

NOTE:—Air was blown in at south end of car during the whole run of six hours and forty-eight minutes. Then fruit was allowed to stand in car without refrigeration for twelve hours. Temperatures were read after this equalization.

TABLE III.

TOKAY GRAPE PRECOOLING IN "WAREHOUSE" CAR. PORTABLE REFRIGERATING PLANT, LODI, CAL., OCTOBER 20–21, 1911.

AVERAGE TEMPERATURES OF FRUIT, DEGREES FAHR.

Time.		Grand Average.	North End of Car.	South End of Car.	Top Tier.	Center Tier.	Bottom Tier.	Center of Package.	Outer Fruit Layer.	Temp. Diff. in Package.
Hr.	Min.									
0	0	63.4	62.4	64.4	64.2	63.7	62.2	62.5	64.4	1.9
3	27	48.5	49.2	47.8	55.2	53.8	36.5	52.2	44.8	7.4
7	35	34.8	32.9	36.8	36.1	38.7	29.8	38.5	31.2	7.3
13	0*	39.3	38.0	40.6	41.2	42.1	34.6	38.6	39.9	1.3

Average temperature of air to car		24.7	degrees Fahr.
Average temperature of air from car		41.0	degrees Fahr.
Average temperature difference		16.3	degrees Fahr.
Net time of air circulation		7.37	hours.
	Max.	Min.	
Temperature of air to car	29.2	20.4	degrees Fahr.
Temperature of air from car	55.0	34.3	degrees Fahr.
Average temperature drop of fruit, total		24.2	degrees Fahr.
Average temperature drop per hour		3.28	degrees Fahr.
Approximate volume of air used, per minute		5320	cubic feet.

NOTE:—Air was blown into car through perforated floor during the first three and one-half hours of run, and in through the perforated ceiling during the next four hours. Then fruit was allowed to stand in car without refrigeration for five and one-half hours. Temperatures were read after this equalization.

TABLE IV.

RED RASPBERRY PRECOOLING IN CAR. PORTABLE REFRIGERATING PLANT, PUYALLUP, WASH., JULY 26, 1911.

AVERAGE TEMPERATURES OF FRUIT, DEGREES FAHR.

Time.		Grand Average.	West End of Car.	East End of Car.	Center of Car.	Center of Package.	Outer Fruit Layer.	Temp. Diff. in Package.
Hr.	Min.							
0	0	67.1	68.4	71.3	61.4	67.0	67.2	0.2
3	55	46.4	48.7	44.4	46.0	46.5	46.2	0.3
7	50*	37.5	39.8	37.4	35.3	37.8	37.2	0.6

Average temperature of air to car		31.2	degrees Fahr.
Average temperature of air from car		39.2	degrees Fahr.
Average temperature difference		8.0	degrees Fahr.
Net time of air circulation		7.43	hours.
	Max.	Min.	
Temperature of air to car	34.4	25.3	degrees Fahr.
Temperature of air from car	48.5	33.4	degrees Fahr.
Average temperature drop of fruit, total		29.6	degrees Fahr.
Average temperature drop per hour		3.98	degrees Fahr.
Approximate volume of air used, per minute		5300	cubic feet.

NOTE:—Air was blown in at east end of car during first half of run and in at west end during last half of run.

TABLE V.

PRUNE PRECOOLING IN WAREHOUSE. ICE AND SALT EXPERIMENTAL PLANT, SALEM, OREGON, SEPTEMBER 12, 1911.

AVERAGE TEMPERATURES OF FRUIT, DEGREES FAHR.

Time.		Grand Average.	Top Tier.	Bottom Tier.	Difference.	Outer Fruit Layer.	Center of Package.	Diff. in Package.	North Side of Room.	South Side of Room.
Hr.	Min.									
0	0	55.9	57.5	54.4	3.1	55.3	56.5	1.2	56.1	55.8
1	0	51.0	54.8	47.3	7.5	49.2	52.8	3.6	50.0	52.1
2	0	47.0	52.1	41.9	10.2	44.9	49.1	4.2	45.4	48.5
3	0	43.4	49.5	37.3	12.2	41.4	45.4	4.0	41.8	45.0
4	0	40.8	47.2	34.3	12.9	39.1	42.5	3.4	39.4	42.2

NOTE:—Air blown into precooling room through perforated floor and withdrawn through ceiling duct.

OBSTACLES TO UNIFORM COOLING.

The figures show at a glance the difficulties of thoroughly refrigerating a large mass of fruit after it is packed. The time limit is all-important and although this may be largely overcome by providing machinery of large capacity, there is a limit beyond which it is impossible to go. By using very large volumes of very cold air the fruit packages can be cooled more rapidly than is the case with smaller volumes of air, or air at higher temperatures. However, as soon as the fruit most exposed to the blast reaches the point where it is likely to be frozen, precooling operations must cease, although the fruit in the interior of the same package may be at a considerably higher temperature, and there may also be packages in the load or in the room where the cooling has not reached to any great extent. Experiment has shown that, depending upon the nature of the fruit and the package in which it is contained, fruits may be safely exposed to an air blast at a temperature many degrees below the freezing point of the fruit for a considerably longer period of time than would be expected. The limitations, however, are sufficient to prevent the equal refrigeration of the entire mass unless, indeed, the circulation of the air can be so managed that every part of the load will be reached.

Precooling conditions are very different from ordinary cold storage conditions. Precooling means quick cooling, and, consequently, requires special equipment to perform the work promptly and quickly. Under ordinary cold storage conditions the cooling may proceed slowly, and when once the contents of the room are reduced in temperature the only work necessary to perform upon that mass is to provide against heat leakage into the room. The efficiency of the insulation, therefore, becomes an important factor. Under precooling conditions, however, heavy work must be performed continuously. The mass of fruit is allowed to remain in the room, or car, only long enough to be refrigerated to the desired point; then a new load is introduced, and so the performance of heavy work must be continuous.

One of the great difficulties encountered in the precooling investigations of the Bureau has been the unequal distribution of the air blast through the carload or room. It has been practically impossible to reach all parts of the load equally. Canvas baffles have been placed in the cars in various positions to force the current of air to pass through the load as much as possible and yet, as shown by

the temperature readings in the different parts of the car, a very unequal distribution of the cold air is made. The temperature conditions within refrigerator cars after precooling, or under ordinary icing methods, are most unequal. There is only a sluggish circulation of the air in the car, depending upon the differences in temperature of the air circulating through the loaded fruit and the cold air passing through the ice bunkers.

There have been a number of patents issued for mechanical contrivances to circulate or to agitate the air artificially within the refrigerator cars. So far none of these has been found practicable, and dependence is still placed upon the natural circulation due to the differences in temperature of air in different parts of the car. This is not sufficient, and I think one of the problems before refrigerating engineers is the working out of some simple, practicable device for air circulation within refrigerator cars.

INADEQUATE INSULATION OF CARS.

Precooling would undoubtedly prove more effective, especially from the railroad traffic standpoint, were it possible to hold the cooled fruit at a uniform temperature throughout the load while in transit. The insulation of refrigerator cars, as at present constructed, seems insufficient to provide against excessive heat leakage into the car, and, consequently, the main duty of the ice is to refrigerate against this heat leakage. Just how far this heat leakage into the car takes place is shown by the temperature readings obtained in the precooling work in California and Oregon. It was found that by allowing the precooled cars to stand for some time after the precooling operations were discontinued, a considerable heat leakage into the car was shown by the fact that the thermometers in the outer layers of fruit in the packages frequently read higher than those reaching into the center of the packages after equalization took place, although before equalization the center thermometers all read higher than those in the exterior layer. How far it will be possible to improve the insulation of cars to offset this heat leakage is a problem which I think is of sufficient importance to command the attention of refrigerating engineers.

One of the effective ways by which the air circulation within the car can be facilitated would be by providing an air space beneath the load. This can be accomplished by means of a false floor, so that the cold air from the ice bunkers may have unrestricted opportunity to flow below the entire mass of fruit loaded in the car.

There are undoubtedly many practical difficulties to overcome in constructing refrigerator cars with false floors, but the problem seems of sufficient importance to warrant some serious work being done along this line. It has also occurred to us that possibly false walls in the car, providing an air space between the load of fruit and the outer car walls, and connected with the space beneath the false floor, would allow the refrigerated air to take care of heat leakage before it had a chance to affect the mass of cool fruit.

These suggestions are made with the hope that they may lead to some careful investigation along these lines on the part of engineers interested in improving fruit transportation facilties.

DISCUSSION.

A. V. Stubenrauch.—In order to show just what the effect of precooling has been in the case of grapes I wish to call your attention to Table I. The fruit was given no special care, in preparing it for shipment, ordinarily handled fruit being used in each case. In the upper line are figures from the precooled shipments and on the lower are those obtained from the regularly iced cars shipped without precooling. A glance at the first two lines shows that there was only a slight difference in the decay between the precooled and non-precooled shipments, even when these inspections were made here in New York after shipment across the continent. There was 6.6 per cent decay in the precooled as against 7.5 in the non-precooled. We made inspections on the day of arrival, two and four days after arrival in market, and you see the results as given in the second and third columns are quite consistent. The same consistency in results followed in the seasons of 1910 and 1911, which seems to corroborate the results obtained in the two previous years.

Again referring to the diagrams of the two cars, one an ordinary refrigerator car, precooled, using the ordinary commercial method of loading, and the other our improvised warehouse car, show the placing of the thermometers in the load in order to obtain the temperature records at various points. The small lines indicate the points where the thermometers were placed. Two thermometers were inserted in each crate or package of fruit, one in an outer layer of fruit, in order to get the temperature of the fruit in the outside portion of the package; the other reaching to the center of the fruit package, in order to determine the actual temperature at that point. The only place where it was practicable to ascertain the temperature of the fruit loaded on the bottom or floor tier of the car was

near the door. The location of these thermometers is also shown on the diagram. In the warehouse car an areaway between the crates was left in stacking the load, and we were able to obtain temperature records at the bottom, at the center, on the top of the load and at each end of the car.

These Tables, II, III, IV and V, were prepared to show the consistency of the temperature differences in different parts of the car. The average differences in temperature shown by all the thermometers placed in the outer and interior portions of the crates were as follows: At the start there was an average difference of 1.7 degrees. The center of the package in that case was cooler than the outer fruit layer. After precooling three hours and fifty-five minutes there was an average difference of 11.9 degrees between the outer and inner layers. At this reading the outer fruit was the colder. After five hours the average temperature difference was 14.1 degrees, and after six hours and forty-eight minutes 15.2 degrees. This car was allowed to stand and the temperature conditions to equalize for about twelve hours, when the temperatures were again read. There was again an appreciable temperature difference between the inside and outside layers of fruit in the crates, but at this reading the outer fruit was 4.1 degrees warmer than that at the center of the package. The equalization had proceeded until all the fruit in the car was practically at the same temperature, and after this condition was reached the outside fruit began to rise in temperature. Practically the same condition of affairs is shown in this second diagram, which represents a refrigerator car loaded with grapes at Lodi, California. Reference to the temperature records obtained in the improvised warehouse car figured above shows a considerable temperature difference between the interior and exterior portions of the packages, but it was not as great as was found in the ordinary refrigerator car, the greatest difference being only 7.4 degrees. After equalization the exterior fruit was at a higher temperature than the interior.

Charles H. Herter.—This temperature difference observed at the end of precooling was caused by insufficient circulation of air, if you had circulated at the rate of, say, 10,000 cubic feet per minute—

A. V. Stubenrauch.—There is a point below which the precooling cannot go, and that is the freezing temperature of the fruit itself. When the fruit in the outer layers of the package, or in the most exposed packages, approaches the freezing temperature the precool-

ing must cease, although there may be a considerable part of the load still at a high temperature.

Charles H. Herter.—Table II shows the in-going air averaged about 26 degrees and the out-going temperature 39 degrees. I think that possibly if you circulated about twice as much air you would have it go in at 30 and come out at 37 degrees.

A. V. Stubenrauch.—With our limited equipment we were not able to increase the volume of air indicated. It is impossible to place baffles in different portions of the load to force the air to go through the tiers of packages. There does not seem to be any practicable way to get the air in through the packages, closely stacked and tightly loaded in the car. We did find that it is possible to expose fruit for a considerable length of time to a blast of air below the freezing point of the fruit itself without material injury, the length of time, of course, depending on the type of package and the nature of the fruit. I might say here that we are trying to devise means of measuring the circulation of air through the car, but it is exceedingly difficult to get accurate readings. I think Mr. Dennis is working on that now.

Charles H. Herter.—By means of Pitot tubes?

A. V. Stubenrauch—By means of Pitot tubes, yes; and he hopes to devise some method by which these can be used.

Again referring to the subject of refrigerator car insulation, just how far this heat leakage takes place is indicated by some of the thermometer readings, which show that within a comparatively short time the temperature of fruit has risen to 44.3 degrees. But, on the other hand, as I pointed out a few minutes ago, we find that the equalization had gone down to a point where all the fruit was apparently of the same temperature; then the temperature of the fruit in outer layers of the packages began to rise. This temperature occurred before the car was moved.

No. 97

THE NON-PRECIPITATION OF CALCIUM CHLORIDE FROM BRINE BY AMMONIA.

By Morgan B. Smith, Syracuse, N. Y.

(Associate Member of the Society.)

At the meeting of the Society held at St. Louis, Mo., October, 1911, the question was brought up as to the effect of ammonia leaks on calcium chloride brines. Statements were made that in several instances, where ammonia had leaked into calcium chloride brine, the calcium had been precipitated out of solution by the action of the ammonia. This precipitate was said to have been of a pasty nature, and was therefore with difficulty removed from the brine tanks in which it formed. I stated at that time in the discussion that I did not believe that calcium chloride would be precipitated in this manner, and that I believed that the brine in question must have contained magnesium chloride as well as calcium chloride. I further stated that calcium chloride would not be precipitated out of solution by ammonia unless carbon dioxide gas was present in some form; also, that I would be pleased to carry out some experiments along that line to learn the exact cause of this precipitation. Since that time I have carried out some very interesting tests and, with your permission, I will now repeat qualitatively some of them.

1. The first brine which I will treat with ammonia is made up with chemically pure calcium chloride. It is of 1.2 sp. gr. You will note that no precipitate forms for a long time, and even after a long period this precipitate is very slight. If we could exclude all air and, consequently, all CO_2 gas, there would be no precipitate at all under these conditions. The precipitate which does form at this time is due to a slight carbonation of the calcium in solution.

2. The second brine which I will treat with ammonia is made up with chemically pure magnesium chloride. It is of 1.2 sp. gr. You will note that there is an immediate precipitation in this brine, the precipitate becoming heavier as the ammonia is passed in. I wish to emphasize at this time that this brine is made from chemically pure magnesium chloride, and that nothing else than magnesium can in any way be precipitated from such a solution. As a

matter of fact, this is just what has happened, the precipitation being magnesium hydroxide.

3. The third brine which I will treat with ammonia is made up with equal parts of the two brines which I have already demonstrated, that is, one-half calcium chloride and one-half magnesium chloride, by volume, of the respective chemically pure brines. On passing ammonia into this composite, or mixed chloride, brine, there is an immediate precipitation similar to that noted above in the case of the chemically pure magnesium chloride brine. As a matter of fact, the two precipitates are the same in composition, namely, magnesium hydroxide. There will also be a slight precipitation of the calcium, due to the carbonation of a small amount of the calcium in solution.

The three experiments carried out so far show that calcium chloride is not precipitated out of solution by ammonia. They show equally well that magnesium chloride is precipitated out of solution by ammonia under the same conditions. They show also that from a mixed chloride brine the magnesium is readily precipitated by ammonia, whereas the calcium is not. It is very evident that a calcium chloride containing magnesium chloride will make a brine from which ammonia will precipitate the magnesium. I will now pass to the commercial chlorides, which are to be obtained on the market for refrigerating purposes.

4. The fourth brine which I will treat with ammonia is made up with a commercial chloride containing 74 per cent. calcium chloride + 0.0 magnesium chloride + 1.0 per cent sodium chloride. It is of 1.2 sp. gr. On passing ammonia into this brine there is no precipitate for a long period. After considerable time there will be a slight precipitation of the calcium, due to carbonation, as was the case with the chemically pure calcium chloride brine.

5. The fifth brine which I will treat with ammonia is made up from a commercial chloride containing 57.62 per cent. calcium chloride + 9.31 per cent.. magnesium chloride + 1.38 per cent. sodium chloride. This also is of 1.2 specific gravity. You will note an immediate precipitation when ammonia is passed into this brine, exactly as was the case with the mixed chloride brine made up with chemically pure chlorides, and in the case of the chemically pure magnesium chloride brine. This precipitate becomes heavier as the ammonia is passed in, and, as in the previous cases, is magnesium hydroxide.

The two commercial brines tested are typical of the two classes of brine in common use in this country, and their behavior in these tests is characteristic of all brines made up with such chlorides as we have used. The chlorides on the market vary to some extent in chemical composition, but not enough so as to form a third class. We can safely conclude, therefore, that the behavior of these brines which we have just tested is typical of all brines made up with our commercial chlorides.

We can safely conclude that when a calcium chloride contains magnesium chloride impurity, it will make a brine from which ammonia will invariably precipitate the magnesium out of solution. This means that with such a brine there will always be the danger that with ammonia leaks the precipitation spoken of at St. Louis will occur. We can equally well conclude that with a brine made up with calcium chloride containing no magnesium chloride there will be no precipitation under the same conditions. We can also conclude that the trouble spoken of at St. Louis caused by ammonia leaking into brine did not occur in a brine containing calcium chloride only. It is also equally certain that the brine, from which ammonia did precipitate the chloride, must have contained magnesium chloride.

The reaction which goes on when magnesium choride is precipitated out of solution as magnesium hydroxide is a variable one, depending on the conditions of temperature, pressure, etc. At times 50 per cent. of the magnesium in solution is precipitated out of solution; at other times as high as 97.5 per cent. can be precipitated out by addition of ammonia.

QUANTITATIVE EXPERIMENTS.

In these quantitative experiments 250 cubic centimeters of the respective brines were used in each case. The ammonia was passed in by distillation from aqua ammonia of 0.9 sp. gr.

6. Brine made up with a chloride containing 57.62 per cent. calcium chloride + 9.31 per cent. magnesium chloride + 1.38 per cent. sodium chloride. It is of 1.2 sp. gr.; 250 cubic centimeters of this brine contained 8.16 grams of magnesium chloride.

Test

1— 4.35 grams NH_3 precipitated 1.75 grams $Mg(OH)_2$ = 2.87 grams $MgCl_2$.
2— 7.25 grams NH_3 precipitated 3.18 grams $Mg(OH)_2$ = 5.22 grams $MgCl_2$.
3—14.50 grams NH_3 precipitated 4.15 grams $Mg(OH)_2$ = 6.81 grams $MgCl_2$.
4—36.25 grams NH_3 precipitated 4.75 grams $Mg(OH)_2$ = 7.79 grams $MgCl_2$.
5—43.50 grams NH_3 precipitated 4.74 grams $Mg(OH)_2$ = 7.78 grams $MgCl_2$.
6—58.00 grams NH_3 precipitated 4.76 grams $Mg(OH)_2$ = 7.80 grams $MgCl_2$.

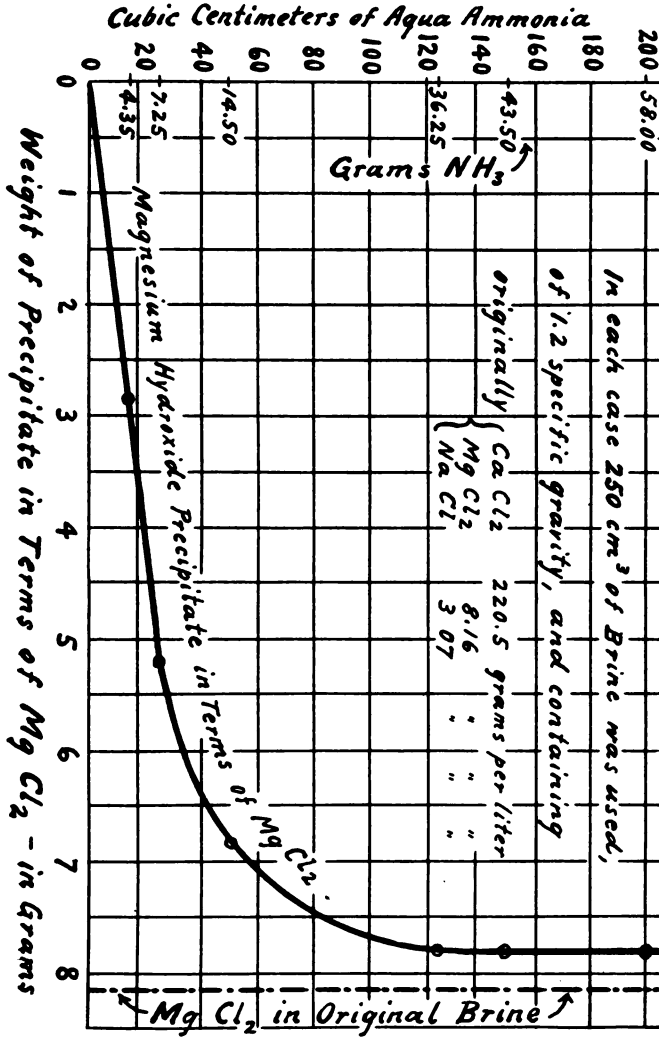
In these tests fully 97.5 per cent. of the total magnesium chloride has been precipitated out of solution by the addition of ammonia.

It is well at this time to point out the fact that the brine resulting after precipitating out the magnesium chloride, being so weakened in chloride content, must possess a decidedly higher freezing point than did the original brine. There is the possibility, therefore, that not only will there be danger of plugging up piping, etc., with the precipitated magnesium hydroxide, but there will also be the additional danger that the brine will freeze, if not solid, at least into a thickly congealed mass.

7. A brine made up from a chloride containing 74 per cent, calcium chloride + 0.0 magnesium chloride + 1.0 per cent. sodium chloride. It is of 1.2 sp. gr. Ammonia was passed into this brine in varying proportions with the same results as noted above with similar brine; namely, a very slight precipitate due to carbonation of the calcium in solution. Some of these tests were carried through out of contact with the air, with the result that no precipitate whatever appeared. When, however, this brine, saturated as it was with ammonia, was exposed to the air for some time the characteristic precipitate due to carbonation of the calcium in solution appeared.

In order that some definite idea might be had of the extremely small amount of this precipitate due to carbonation, an experiment was carried through in which 750 cubic centimeters of this brine, containing no magnesium chloride, was treated with ammonia distilled from 200 cubic centimeters of aqua ammonia of 0.9 sp. gr. The resulting solution, pretty well saturated with ammonia, was then allowed to stand in a shallow twelve-inch dish, giving a large surface exposed to the air. Under such conditions, which were very severe, in an atmosphere containing CO_2 in excess of normal, a precipitate did appear after twelve hours. This precipitate weighed 0.0450 grams per 750 cubic centimeters of the brine used, which is equivalent to 0.0150 grams per 250 cubic centimeters, the basis of the former experiments. When this extremely small precipitate is compared with that formed under the same conditions with the brine containing magnesium chloride, namely, 4.76 grams $Mg(OH)_2$, equivalent to 7.80 grams $MgCl_2$, it is seen at once that this secondary precipitation due to carbonation is an entirely negligible quantity.

In conclusion, let me advise all who operate refrigerating plants using calcium chloride to acquaint themselves with the true nature of the chloride which they purchase. A competent chemist can


Cubic Centimeters of Aqua Ammonia
0 20 40 60 80 100 120 140 160 180 200
4.35 7.25 14.50 36.25 43.50 58.00
Grams NH_3
In each case 250 cm³ of Brine was used,
of 1.2 specific gravity, and containing
originally
Ca Cl2 220.5 grams per liter
Mg Cl2 8.16 " " "
Na Cl 3 07 " " "
Magnesium Hydroxide Precipitate in Terms of Mg Cl2.
0 1 2 3 4 5 6 7 8
Mg Cl2 in Original Brine
Weight of Precipitate in Terms of Mg Cl2 - in Grams

always tell you when magnesium chloride is present, and can help you to avoid such difficulties as have been met with in the use of chlorides containing magnesium chloride, as well as calcium chloride.

The following table, showing the freezing points of various commercial brines at different densities, is interesting:

DEPARTMENT OF COMMERCE AND LABOR.
BUREAU OF STANDARDS, WASHINGTON, D. C.

Test No. 6,636.

Commercial Chlorides for Refrigeration Uses.

TABLE OF FREEZING POINTS.

	3 Lbs. Per Gal.		3.5 Lbs. Per Gal.		4.0 Lbs. Per Gal.	
SAMPLE.	°C.	°F.	°C.	°F.	°C.	°F.
No. 1	—20.0	—4.0	—26.5	—15.7	—34.0	—29.0
No. 2	—19.0	—2.2	—25.0	—13.0	—32.0	—25.6
No. 3	—22.5	—8.5	—30.0	—22.0	—39.0	—38.2
No. 4	—21.0	—5.8	—28.0	—18.4	—35.5	—31.9
No. 5	—20.5	—4.9	—27.5	—17.5	—35.0	—31.0

ANALYSES OF THE CHLORIDES TESTED.

SAMPLE.	$CaCl_2$.	$MgCl_2$.	NaCl.	Total Chlorides.
No. 1.....	43.52	18.85	0.13	62.50
No. 2.....	48.08	14.91	0.74	63.73
No. 3.....	74.50	0.00	0.50	75.00
No. 4.....	53.90	12.12	0.39	66.41
No. 5.....	55.12	9.94	0.56	65.62

All the above samples were purchased in the open market and are supposedly representative of respective brands.

Calcium chloride itself is a very valuable material for use in our refrigerating plants, and, if used intelligently, will give excellent results. Calcium chloride, if contaminated with magnesium chloride, will be sure to cause trouble with ammonia leaks. Many of these chlorides are called calcium chlorides. A better name would be composite, or mixed chlorides, or, better still, calcium-magnesium chlorides, which would then describe their true nature.

In presenting these experiments I hope that I have cleared away all doubt as to the cause of the precipitation in brines due to ammonia leaks.

DISCUSSION.

George A. Horne.—Will the brine composed of ½ $CaCl_2$ (C. P.) +½ $MgCl_2$ (C. P.) show a lower freezing point than that brine which contains $CaCl_2$ only?

Morgan B. Smith.—Probably it will. But there are no commercial chlorides on the market which will produce such a brine. My paper contains a table which shows comparative freezing points

of our various commercial chlorides, comparing one chloride containing no $MgCl_2$ with others containing both $MgCl_2$ and $CaCl_2$.

John C. Sparks.—The point you want to bring out is, isn't it, that the difference, taking the freezing point only, is with a greater amount of calcium chloride, very much more than the balance of difference between the calcium and magnesium chlorides, when considering the other things? That is the point. Why, in these experiments just now, did you use chemically pure salts?

Morgan B. Smith.—That is the point exactly. The only reason I used chemically pure salts, that is, chemically pure calcium chloride and chemically pure magnesium chloride, was simply to demonstrate that in the case of chemically pure calcium chloride there is no precipitate, emphasizing the point that there is no other salt present, being just as near absolutely pure as you can make it by chemical process, and to demonstrate that in the case of chemically pure magnesium chloride there is a precipitation, emphasizing the fact that there is no salt present other than magnesium chloride. Therefore when you mix chemically pure calcium chloride and chemically pure magnesium chloride and get a precipitate, that precipitate must be due to the presence of magnesium chloride.

E. L. Phillips.—I would like to ask you if there is such a thing as getting too much calcium in solution and raising the freezing point?

Morgan B. Smith.—Yes.

George A. Horne.—It occurs to me there is some advantage in the magnesium chloride, unless there are other disadvantages in the precipitate of magnesium hydroxide. The brine cooler is the place where you would ordinarily have a leak and have brine coming in contact with the gas. Wouldn't it do to have a gauge glass on the cooler, and then when you see the precipitate appearing in your gauge glass you know you have the ammonia where you don't want it?

Morgan B. Smith.—You know you would have a leak.

John C. Sparks.—May I ask a question? There was a plant in New York City which operated a very short time, only a question of weeks, and there was a precipitate of carbonate of calcium. Was that a mixed chloride?

Morgan B. Smith.—Yes.

John C. Sparks.—There was no ammonia, the solution was slightly acid, very, very slightly. There was so much precipitate in

that tank that Mr. Vesterdahl told me it was more than a foot thick. Can you account for that?

Morgan B. Smith.—Do I understand that the carbonate was present in the original chloride as sold on the market?

John C. Sparks.—That I do not know. I only know about the brine that was in the tank. There was so much carbonate present it did not seem possible it could be absorbed from the air. That was not an alkaline solution from the absorption of ammonia. It was practically a new plant.

Morgan B. Smith.—You say the solution was *very* slightly acid?

John C. Sparks.—Yes.

Morgan B. Smith.—Otherwise you would not have a precipitation of calcium carbonate in an acid solution. The slight acidity noted may have been caused by the presence of bicarbonates. I cannot explain it except that it was due to the varying quality of some of these calcium and magnesium chlorides that are sold on the market. There is no question that a great many of the calcium and magnesium chlorides vary a great deal in composition.

John C. Sparks.—It had been running only a few weeks. It was impossible to get it from the water. New York City water contains a grain and a half of carbon dioxide.

Morgan B. Smith.—That would not account for it.

John C. Sparks.—Could not possibly.

Morgan B. Smith.—I would say, without further investigation, that that lot of drums was filled with chalk rather than calcium chloride, which is a good argument in favor of purchasing chlorides which run uniform in quality.

John C. Sparks.—It was sufficient to absolutely stop the coils.

No. 98

THE RELATIVE IMPORTANCE OF HANDLING AND REFRIGERATION IN THE PRESERVATION OF PERISHABLE FOODSTUFFS.

By M. E. Pennington, Philadelphia, Pa.

(Non-Member of the Society.)

I have rather a guilty feeling that I am here and have enjoyed your meeting and accepted your hospitality under false pretenses. Some time ago your Secretary wrote and asked if I would attend the meeting and also deliver an address. That is rather a terrifying term and so I replied that I would gladly attend the meeting and I would also gladly attempt to answer any questions that any of the members might have to put concerning our work, but as I was already swamped with work I must ask to forego an address this year. I might perfectly well have said that I was unequal to preparing an address befitting so dignified and distinguished an audience. When I returned from the West last week I found a reply to my letter in the shape of the program of the meeting, which states that I am to make an address on "Recent Investigations of the Food Research Laboratory of the United States Department of Agriculture."

Now I am quite too proud of the members of the staff of the Food Research Laboratory to risk leaving with you a false impression of their activities by trying to give an account of their research work. However, I have a few ideas of my own concerning refrigeration that I have long been anxious to bring to those who were particularly interested in that subject, namely, the relation between the efficiency of refrigeration and the careful handling of perishable products. I am more than glad to be able to make this statement from the viewpoint of the handling of poultry and eggs, because Mr. Stubenrauch has already brought it to your attention on the score of the handling of fruit, and through his investigations, which are so far removed from the investigations which we have been conducting, he comes to the same conclusions that we have reached, and therefore we may be doubly sure of their correctness.

The aim of the Food Research Laboratory may be said to be threefold; namely, the utilization, the conservation and the betterment of foodstuffs. In our study of perishable products we find that two forces, combined, produce the most satisfactory results. These forces are careful and judicious handling and properly applied refrigeration. I have put good handling first because the study of the marketing of perishables in general has convinced me that it is the most important factor. Combined with proper handling, refrigeration completes and emphasizes the results sought; but dependence upon refrigeration, alone, to carry perishables from the producer to the consumer results in the failures and the dissatisfaction that have undeservedly been laid at the door of refrigeration. As refrigerating engineers you are, of course, engaged in the problems of refrigeration, proper. May I, therefore, point out certain phases of our work which will emphasize the fact that handling, as distinct from refrigeration, cannot be neglected if desirable results are to be attained?

IMPROVED METHODS OF HANDLING POULTRY AND EGGS.

The laboratory has at the present time some field workers in Tennessee, studying the handling of poultry and eggs. We worked there all last summer, the long continued and unusually high temperatures furnishing excellent conditions under which to do experimental work on perishables, since the ordinary commercial methods were inadequate to the point of extinction. Early in the spring, before the coming of hot weather, the packers were urged to starve the birds for 24 hours before killing, that readily putrefiable material might be removed from the intestines. Then killers were trained to cut the blood vessels of the chickens in such wise as to drain the tissues as thoroughly as possible of blood, and to pick off the feathers without tearing or rubbing the skin. In all the work in the killing room cleanliness was made the watchword. Blood was not allowed to drip from one bird on to another; they were not allowed to touch any surface after killing, but were picked suspended by the legs and then hung, again by the legs, on an all-metal rack which permitted of absolute cleanliness and a free circulation of air around each bird. The hotter the day, the greater the speed between the killing room and the chillroom, where a temperature of below 38 degrees Fahr.—generally about 33 degrees Fahr.—was maintained, and from which the birds were finally packed at a temperature of 30 degrees to 32 degrees Fahr.

When the trucks reached the chillroom our anxiety ended, provided the previous handling had been satisfactory; otherwise, no amount of refrigeration would get those chickens to market with the bloom and finish that makes them desirable to the purchaser. Blood left in the mouth or on the head will decompose in spite of good chilling; dirty feet, pressing against the flesh of a neighboring chicken in the package, will taint its fine flavor, even though it be kept cold continuously. Soiled skins lose their bright color and "bloom" in spite of refrigeration, and if bleeding is incomplete, red blotches and flabby flesh are sure to mar the product.

If, however, the preparation of the fowl for chilling has been according to approved methods, what can refrigeration do to assist in the getting of that fowl to the consumer in excellent order? Perhaps some statements concerning our experimental shipments from Tennessee to New York during the past summer will serve as the best illustration that I can give of the value of refrigeration in the marketing of poultry.

EXPERIMENTAL SHIPMENTS.

Once a week throughout the summer a carload of dry-picked, dry-packed poultry, dressed and chilled as I have indicated, was sent North. In this car was contained the regular commercial pack and also some birds which had been dressed under the direct supervision of the members of the laboratory staff, and had been examined in the laboratory at the packing house before shipping. They were again examined when they arrived in New York and were traced through the markets to the consumer, laboratory examinations being made at every change of environment.

One car during the summer arrived in bad order because the railroad had failed to ice it. Good handling in the packing house was not enough to obviate the need for refrigeration. However, most of the poultry was still salable though of a much lowered grade. All the other cars arrived with the birds in good order throughout, and in surprisingly good condition near the bunkers, where the temperature approximated that of the packing house chillroom. Such birds were good food almost three weeks after killing, even during the unprecedented heat of July. At no time during marketing were they frozen. The unbiased findings of the laboratory showed that bacteriologically and chemically the changes in the composition of the flesh of these well handled, well refrigerated birds were actually less than in that of birds badly handled and on the market for scarcely half the time of the experimental shipments.

What it means to those Southern States to be able to ship perishable produce North can hardly be computed at the present time. Tennessee and Kentucky, especially, would seem to be the coming poultry section of this country. They are awake to that fact, and the improvements in methods, the broadening of outlook and the avidity with which new and progressive ideas are absorbed and applied indicates phenomenal achievements in the near future. Refrigeration is, and must continue to be, of the utmost importance in the development of this territory where summer is long; and even in the wintertime there are many days which are too warm to permit of using the atmospheric temperatures for chilling purposes. The comparatively few plants equipped with artificial refrigeration are very new; yet, even so, they find it indispensable and the character of their output has already been revolutionized.

The effect of good handling and refrigeration on the output of Southern eggs has been even more marked than the effect on poultry. Tennessee and Kentucky ship eggs North during the winter months when the supply from other sections has almost ceased. When warm weather comes the eggs in the past have gone still further south, where standards in eggs are not so high, or into the fertilizer pile. Last summer a few shippers, provided with artificial chilling facilities shipped eggs North for a great part of the summer, and found it profitable. They combined a campaign for careful, quick handling and maintained low temperatures as soon as possible after laying. They found that once thoroughly heated, so that the processes which make for incubation had begun, or in the infertile egg, the deteriorative course induced by heat, refrigeration cannot check nor even greatly retard such changes. Hence, eggs which had been subjected to unfavorable conditions would change en route, even though refrigerated, to such an extent that the packer would not recognize them when they reached their market. If, however, they were well chilled when fresh, deterioration during an average haul under refrigeration was almost a negligible quantity, commercially speaking.

All of our experimental shipments of eggs have confirmed and emphasized our observations on the results obtained by the industry. We find that such factors as dirty shells, wet nests, damp cellars, etc., cannot be overcome by refrigeration, and that the egg must go to the cooler in good condition whether it be for prompt marketing or for long storage, if the maximum benefit of the low temperature is to be secured.

DISCUSSION.

Henry Torrance, Jr.—I would like to ask Dr. Pennington what is the result of cold storage on an egg that is gathered fresh and then promptly put into a room that is maintained at 32 degrees for six months; whether the average person can tell the difference between that and a fresh egg?

M. E. Pennington.—We do not consider 32 degrees a desirable temperature, Mr. Torrance. We maintain egg storage rooms ordinarily between 29 and 31 degrees. An egg which goes in fresh and is well kept for six months can generally be detected by an egg expert, but those who eat ordinary "strictly fresh" city eggs I think cannot be generally depended upon to tell the difference, provided the egg had been well stored.

John E. Starr.—I would like to ask Dr. Pennington if, in her experience with the transportation of perishable goods by refrigerator cars, she has found the cars which are at present in use, the present refrigerated rolling stock, adequate and satisfactory for the purposes for whch they are intended?

M. E. Pennington.—I think it is generally recognized, Mr. Starr, that nearly all the cars in present use have too high a temperature in the middle of the car. They are efficient near the ice bunkers and they are efficient in the lower part of the load; but when it comes to the portion of the car in front of the doors and the higher part of the load there is still much to be desired in the ordinary refrigerator car.

Eugene W. Lewis.—What Dr. Pennington says about the uneven temperatures in refrigerator cars is true. I have known as high as 18 degrees difference in temperature between the floor and ceiling. That there is not proper circulation has already been brought out in the fruit preccoling experiments.

M. E. Pennington.—We have found this variation. I do not mean that this is the ordinary variation, but does happen sometimes; there is a temperature of 10 degrees at the bottom of the car near the ice bunker and 55 in the middle of the car at the top of a four-foot load.

Eugene W. Lewis.—In the case of incoming celery or California fruits, the top layer sells for 25 per cent. less than the lower layers, due to the high temperatures at the top of the cars.

Charles H. Herter.—In the published reports of the interesting investigations made by the Government, the record of temperatures maintained in the cold storage rooms are usually quite complete; the

only unknown factor remaining being that of the relative humidity of the cold air. We are aware that the measuring of humidity is much more difficult than that of temperatures, but it is known that a low temperature alone does not always insure the keeping quality of some of the products stored. Humidity, therefore, must receive its share of attention. Madison Cooper believes that eggs stored at, say, 40 degrees Fahrenheit and 53 per cent. relative humidity would keep as well as if stored at 28 degrees Fahrenheit and 80 per cent. humidity. In Germany hops are stored at 32 degrees Fahrenheit and 50 per cent., and in England at 26 degrees Fahrenheit and 65 per cent. relative humidity; the air containing in each case about one grain of moisture per cubic foot. The results are said to be equally satisfactory. If a moderate degree of dryness allows us to use higher temperatures a distinct gain will follow, because a ton of refrigeration at a higher temperature costs less than at a lower temperature. The loss through insulation is also reduced, the goods need not be cooled through so many degrees and the machine is able to work to better advantage.

If it is not found advisable to increase the storage temperature, the maintaining of suitable humidity will surely influence the keeping quality favorably. In Europe the proper relative humidity for fresh fruits and green vegetables is claimed to be 60 to 70 per cent., and for lemons and dried fruit 65 to 75 per cent. But these statements are of little use so long as we do not know the accompanying temperature. Rate of air change also must have some bearing upon the matter of food preservation.

Eugene W. Lewis.—I believe you quote Madison Cooper as stating that in a temperature of 40 degrees, with a relative humidity of 53 per cent., eggs would keep as well as at a temperature of 28 with a humidity of 80 per cent. That is not so, for this reason: At the lower temperature, 29 to 30 degrees, the white or albumen of the egg has stiffened to such a degree that the yolk is maintained in its natural position during the three to six months that eggs are in storage. If they are carried at 40 degrees that condition could not exist. In the days of natural ice storage, when they carried eggs around 38 degrees, they were compelled, every ninety days, to reverse the eggs, so that the yolk would not rise and touch the shell. It does not sink, as people think; it rises. I carried the first egg at 29 degrees in 1893 and have been doing it ever since.

Charles H. Herter.—I merely wanted to emphasize the importance of getting the proper relative humidity. You might have a room which is too damp.

Eugene W. Lewis.—With a temperature of 29 to 30 degrees there does not seem to be an instrument which will measure the humidity. If we use the ordinary wet and dry bulb instrument it freezes. If you use alcohol it changes the reading altogether. I do not see how you are going to get at the proper reading.

Charles H. Herter.—Don't you get approximately correct readings with a hair hygrometer?

Eugene W. Lewis.—You cannot get them with a hair hygrometer. Those things are too erratic.

Henry Torrance, Jr.—I understand that Mr. Starr does not agree with Mr. Lewis' statement, that there is no hygrometer at the present time that reads at 29 degrees.

John E. Starr.—I regret to state, very reluctantly, that I will have to agree with Mr. Lewis. I have been at work for the last two or three years on such an instrument, and Dr. Pennington asks me about it once every time we meet, sometimes twice. I hope sometime to be able to get such an instrument, but so far as I know there is no instrument at the present time that will register accurately the humidity at about 29 degrees which would be available in ordinary cold storage work.

Eugene W. Lewis.—Mr. Starr, did you ever get three readings alike with a sling psychrometer?

John E. Starr.—No, I never did in the cold storage room.

Frank A. Horne.—It seems to me that high temperature and low humidity both contribute to the shrinkage in the egg and that a lower temperature of from 29 to 30 degrees is the only thing.

Eugene W. Lewis.—Most of the shrinkage is caused by evaporation due to circulation of the air.

Dr. Lucke.—It might be of interest, since the subject of humidity has come up, to call the attention of the members to the fact that on Friday morning, in this building, at the Friday morning session of the Mechanical Engineers' Society, there will be a paper on Rational Psychrometric Formulae, by Mr. Carrier. Mr. Carrier has developed the theory for relating the dew point temperature to the temperature of saturated vapor, which may make it possible to extend tables to the use of alcohol, which cannot now be done. If his theory proves sound—after the meeting we will be able to tell fairly well about that—the next step will be to apply it to alcohol vapors and other non-freezing vapors in use in this connection. The psychrometric tables of the Weather Bureau, which everybody uses, are purely empiric. There is no purely thermometric foundation for them. Carrier is applying another theory.

IN MEMORIAM

	Born	Died
Blethen, Henry,	February 27, 1857	April 24, 1909
Boyer, Francis H.,	September 6, 1845	February 21, 1909
Collins, John Glenn,	July 28, 1854	April 19, 1908
Gould, Ovid M.,	April 23, 1838	February 21, 1911
Hier, Frank T.,	July 6, 1859	February 2, 1912
King, Rockwell,	1853	July 27, 1905
Maschwitz, Carlos.	May 7, 1862	1911
Siebert, Alfred,	1853	July 20, 1909
Smart, John M.,	August 8, 1866	April 14, 1912
Smith, Edmund J.,	October 21, 1856	September 17, 1906
Tough, L. M.,	1846	April 15, 1911
White, Frank H.,	September 22, 1874	May 26, 1907
Willis, James,	April 30, 1845	March 29, 1910

LIST OF MEMBERS

*Abbey, Frank H. (1908), 7 Pelham Terrace, Arlington, Mass.

Aday, F. M. (1911), Fred W. Wolf Company, 50 Church street, New York, N. Y.

§Affleck, William B. (1906), Keystone Engineering Works, 719 Noble street, Philadelphia, Pa.

*Allen, Philip R. (1905), F. W. Bird & Son, East Walpole, Mass.

Allison, C. E. (1911), Canadian Ice Machine Co., 163 Yonge street, Toronto, Canada.

Armour, Norman H. (1911), 6110 Vernon avenue, Chicago, Ill.

Armstrong, C. G. (1911), 149 Broadway, New York, N. Y.

Ashton, Walter S. (1907), St. Louis Brewing Association, 703 Wainright building, St. Louis, Mo.

*Atwood, John C. (1905), The National Ammonia Company, 3600 North Broadway, St. Louis, Mo.

Aue, J. E. (1904), De La Vergne Machine Company, foot of East One Hundred and Thirty-eighth street, New York, N. Y.

§Baars, Ernst S. H. (1907), Vilter Manufacturing Company, 872 Clinton street, Milwaukee, Wis.

§ Bach, Charles G. (1911), 672 Buffum street, Milwaukee, Wis.

Baer, Alvin H. (1905), Brick Company, Waynesboro, Pa.

Ball, P. De C. (1904), (Vice-President 1905 '06), 3003 North Broadway, St. Louis, Mo.

Bates, Guy (1909), Summit & Madison Ice Company, Summit, N. J.

Bauer, Ferdinand (1911), 4131 Meramac street, St. Louis, Mo.

§Bavier, Robert N. (1909), Knickerbocker Ice Company, 1170 Broadway, New York, N. Y.

*Bavier, William N. (1909), Knickerbocker Ice Company, 1170 Broadway, New York. N. Y.

Becker, Jr., Victor H. (1909), Pilsbry-Becker Engineering Company, 200 North Main street, St. Louis, Mo.

Becker, Victor H. (1904), (Director), 431 South Dearborn street, Chicago, Ill.

Behn, Carl (1904), (Director), Buffalo Refrigerating Machine Company, 126 Liberty street, New York, N. Y.

Bein, G. F. (1909), 602 Wheat building, Forth Worth, Tex.

Berna, George (1904), 140 Giles street, Ithaca, N. Y.

*Berryman, Robert J. (1909), Annapolis, Md.

Bertsch, J. C. (1904), P. O. Box 417, Fort Worth, Tex.

*Binzel, Jr., Peter (1909), United Cork Companies, 50 Church street, New York, N. Y.

Bishop, A. C. (1907). 321 Citizens building, Cleveland, Ohio.

Block, Louis (1904), (Director 1905-'08, President 1909, Director), 45 East Forty-second street, New York, N. Y.

Borchers, Herbert L. (1911), 2007 Baird avenue, Portsmouth, O.
Borgstedt, Henning N. (1905), 67 Park avenue, Yonkers, N. Y.
*Bost, William David Ashton (1906), Cartvale Chemical Works, Paisley, Scotland.
Botchford, H. J. (1905), Carbondale Machine Company, 1329 Candler building, Atlanta, Ga.
*Bower, William H. (1911), Henry Bower Chemical Manufacturing Company, 2815 Gray's Ferry road, Philadelphia, Pa.
*Bowers, James (1910), 106 West Eighteenth street, Wilmington, Del.
*Bracken, J. H. (1908), Union Insulating Company, Great Northern building, Chicago, Ill.
*Bridgette, R. E. (1911), 261 Bond street, Brooklyn, N. Y.
*Briggs, John N. (1907), Coeymans, N. Y.
§Broas, Richard S. (1910), Starr Engineering Company, 90 West street, New York, N. Y.
Brostrom, Gustav R. (1909), 529 Linden avenue, York, Pa.
*Brownell, C. H. (1905), Washington Court House, Ohio.
*Burhorn, Edwin (1905), 71 Wall street, New York, N. Y.
Carpenter, Martin R. (1904), Triumph Ice Machine Company, Oakley, Cincinnati, Ohio.
*Case, Charles L. (1904), (Director), Boston Terminal Refrigerating Company, 239 Sumner street, East Boston, Mass.
§Cavnah, H. E. (1907), 55 Avenue Victor Hugo, Paris, France.
Chatard, William M. (1909), Chatard & Norris, 1412 Continental building, Baltimore, Md.
Church, Fred B. (1904), 37 Wall street, New York, N. Y.
Cochran, Heywood (1909), Carbondale Machine Company, 431 South Dearborn street, Chicago, Ill.
§Cole, Donald (1907), Timken-Detroit Axle Co., Detroit, Mich.
*Cole, Harold W. (1904), 9 Mountain Terrace, Upper Montclair, N. J.
Cooper, Madison (1904), (Director 1909-'11), Calcium, N. Y.
*Criss, Charles L. (1906), Liberty and Second avenues, Pittsburgh, Pa.
Criswell, A. P. (1904), P. O. Box 435, Chicago, Ill.
*Croll, Cecil H. G. (1905), 18 Mersey street, Island Bay, Wellington, N. Z.
Daly, Benjamin F. (1905), Hollands, Rockaway Beach, N. Y.
§Day, Abram (1910), 160 Williamson avenue, Bloomfield, N. J.
De Hart, Jr., John S. (1904), Isbell-Porter Company, 46 Bridge street, Newark, N. J.
De Kinder, J. J. (1904), (Director 1907-'09), Lennox Apartments, Atlantic Avenue, Atlantic City, N. J.
§Delareuelle, G. H. (1909), United Iron Works, Oakland, Cal.
§Delle, Frank A. (1907), Pilsbry-Becker Engineering & Supply Company, 200 North Main street, St. Louis, Mo.
Dettmar, E. (1908), 6254 Jackson Park avenue, Chicago, Ill.
Dickerman, Charles (1904), (Director), Twenty-sixth street and Susquehanna avenue, Philadelphia, Pa.
§Dickinson, Raymond N. (1907), Hubbard & Co., 575 Mission street, San Francisco, Cal.

Doelling, Louis (1908), (Director), De La Vergne Machine Company, foot of East One Hundred and Thirty-eighth street, New York, N. Y.

Dorr, A. L. (1907), Armstrong Cork Company, 84 North street, Boston, Mass.

*Dreyer, Oscar (1911), Rjasan Ooralsk Railway, Saratov, Russia.

*Dunning, George A. (1910), Standard Ice Manufacturing Company, Twenty-seventh and South streets, Philadelphia, Pa.

*Ely, James (1905), Hohmann & Maurer Manufacturing Company, 31 Union Square, New York, N. Y.

§Fagnan, D. L. (1906), 1613 Carter building, Houston, Tex.

*Feilberg, Nicolai L. (1910), 903 South Oak Park avenue, Oak Park, Ill.

Fisher, George H. (1909), Leavenworth, Kan.

Flocke, Frank J. (1904), 791 East One Hundred and Seventy-fifth street, New York, N. Y.

Fowler, A. M. (1910), United Iron Works, 151 North Los Angeles street, Los Angeles, Cal.

Frantz, Samuel R. (1905), 219 West Main street, Waynesboro, Pa.

Frick, Ezra (1904), Clayton avenue, Wayneboro, Pa.

Friedmann, Edward N. (1904), (Director 1910, President 1911, Director), 90 West street, New York, N. Y.

Gallenkamp, Jr., Edward W. (1911), St. Louis Refrigerating & Cold Storage Company, St. Louis, Mo.

Gardiner, Edward J. (1906), Harrow road, Bexley, Sydney, New South Wales, Australia.

Geisler, George H, (1909), United Iron Works, Second and Jefferson streets, Oakland, Cal.

*Glover, J. Graham (1905), 166 State street, Brooklyn, N. Y.

*Golden, Albert J. (1908), Industrial Cold Storage & Warehouse Company, American and Berks streets, Philadelphia, Pa.

Goodmanson, Frank A. (1907), La Plata Cold Storage Company, Ltd., Pureto La Plata, Argentine Republic.

Goosmann, J. C. (1904), 172 Washington street, Chicago, Ill.

Gray, John Lathrop (1909), Tide Water Oil Company, East Twenty-second street, Bayonne, N. J.

§Greene, Van Rensselaer H. (1905), De La Vergne Machine Company, foot of East One Hundred and Thirty-eighth street, New York, N. Y.

§Guckel, Charles H. (1906), Springfield Gas & Electric Co., Woodruff building, Springfield, Mo.

Hague, John (1911), 1228 Pine street, St. Louis, Mo.

*Haire, David E. (1905), 2128 Land Title building, Philadelphia, Pa.

Hargreaves, William (1905), De La Vergne Machine Company, foot of East One Hundred and Thirty-eighth street, New York, N. Y.

*Hausmann, Carl (1909), 13 Featherstone Terrace, Wellington, N. Z.

Haven, Harry M. (1904), F. W. Dean, Inc., 53 State street, Boston, Mass.

Havenstrite, Charles D. (1908), H. W. Johns-Manville Company, 322 North Michigan avenue, Chicago, Ill.

*Herst, Franklin H. (1905), Twenty-ninth and Market streets, Philadelphia, Pa.

*Hexamer, William E. (1908), Vilter Manufacturing Company, 864 North Franklin street, Philadelphia, Pa.

§Hill, John (1911), Shipley Construction & Supply Company, 90 West street, New York, N. Y.

*Hill, Walter L. (1905), 110 State street, Boston, Mass.

Hiller, N. H. (1904), (Director 1909-'11), Carbondale Machine Company, Carbondale, Pa.

§Hoffman, C. E. (1907), 622 Beatty building, Houston, Tex.

§Hoffmann, W. John (1911), 1014 Washington street, Hoboken, N. J.

Holden, D. L. (1904), Viscosity Ice Machine Company, American National Bank building, Indianapolis, Ind.

*Holzbaur, W. L. (1907), 2610 Brooklyn avenue, Kansas City, Mo.

*Hoos, William (1907), 143 North Front street, Philadelphia, Pa.

*Horne, Frank A. (1907), (Treasurer), 161 Chambers street, New York, N. Y.

*Horne, George A. (1911), 161 Chambers street, New York, N. Y.

Hoshino, Ichizo (1911), Takata & Co., Ichome Yurakucho, Tokyo, Japan.

*Hovey, Charles A. (1909), United Cork Companies, 50 Church street, New York, N. Y.

*Hughes, John L. (1909), Yakima Artificial Ice & Cold Storage Company, North Yakima, Wash.

Hunter, George C. (1907), 1392 West Third street, Cleveland, Ohio.

Huntley, Clifford E. (1908), 103 Park avenue, New York, N. Y.

Jacobus, D. S. (1904), (Director 1905-'06, President 1907), Babcock & Wilcox Company, 85 Liberty street, New York, N. Y.

§Jaeger, A. P. (1908), 2122 California street, Omaha, Neb.

§Jamison, Jr., J. V. (1908), Jones Cold Store Door Company, Church and Foundry streets, Hagerstown, Md.

Jenks, L. Howard (1904), (Director 1905-'07), Frick Company, 39 Cortlandt street, New York, N. Y.

*Johnson, Albert (1906), 2635 Hampden court, Chicago, Ill.

§Karl, Robert H. (1910), 4620 Vernon avenue, St. Louis, Mo.

Kerbel, C. Joseph (1910), Central Consumers Company, Louisville, Ky.

Kilian, Justus (1907), Vilter Manufacturing Company, 872 Clinton street, Milwaukee, Wis.

Kolischer, Theodore (1907), Central Construction & Supply Company, 140 North Tenth street, Philadelphia, Pa.

Kremer, Waldemar R. (1907), Vilter Manufacturing Company, Milwaukee, Wis.

Krum, Charles L. (1904), 421 North State street, Chicago, Ill.

Laichinger, John (1911), 1214 Liggett building, St. Louis, Mo.

Lane, George H. (1910), Shipley Construction & Supply Company, 90 West street, New York, N. Y.

Langley, Frank W. (1911), United Iron Works, 151 North Los Angeles street, Los Angeles, Cal.

Levey, John (1904), National Machine Works, North and Sheffield avenues, Chicago, Ill.

*Lewis, Eugene W. (1907), 6053 Woodlawn avenue, Chicago, Ill.

§List, Leonardo J. (1908), 864 North Franklin street, Philadelphia, Pa.

*Livezey, John R. (1907), 1933 Market street, Philadelphia, Pa.
*Loney, Luxton (1906), Equitable building, Sydney, Australia.
*Long, E. L. (1911), Armstrong Cork Company, Powers building, Rochester, N. Y.
Louis, J. S. (1904), Triumph Ice Machine Company, Oakley, Cincinnati, Ohio.
Lucke, Charles E. (1908), (Vice-President 1910-'11), Columbia University, New York, N. Y.
§Luedicke, Alexander H. (1911), 1011 Richards street, Milwaukee, Wis.
Luhr, Otto (1906), 4024 Clarendon avenue, Chicago, Ill.
*Lynch, John H. (1907), 17 South William street, New York, N. Y.
*McCarthy, George L. (1904), 116 Nassau street, New York, N. Y.
*McDaniel, Homer (1905), (Vice-President 1909-'10), Sheriff Street Market & Storage Company, 2235 East Fourth street, Cleveland, Ohio.
*McDougall, A. M. (1909), Northern Cold Storage & Warehouse Company, Seventh avenue, West, and Railroad street, Duluth, Minn.
§McKee, Thomas C. (1907), Carbondale Machine Company, 431 South Dearborn street, Chicago, Ill.
*McPartlin, Stephen E. (1905), 20 West Jackson boulevard, Chicago, Ill.
*McPike, Eugene F. (1909), American Railway Perishable Freight Association, Lord building, 1200 Michigan avenue, Chicago, Ill.
Manns, W. H. (1904), (Director 1909-'11), 219 West Second street, Waynesboro, Pa.
Markel, E. J. (1905), Room 30, 739 Chapel street, New Haven, Conn.
Marshall, A. T. (1909), 53 Oakland Terrace, Hartford, Conn.
*Marshall, Lewis C. (1905), 178 Devonshire street, Boston, Mass.
Matthews, F. E. (1904), Leonia avenue, Leonia, N. J.
Mayer, Fred W. (1908), Mayer Ice Machine & Engineering Company, Jersey City, N. J.
*Meeske, William (1911), 700 East One Hundred and Sixty-third street, New York, N. Y.
Meltzer, Arthur (1905), 418 H. W. Hellman building, Los Angeles, Cal.
Miller, Edward F. (1910), Massachusetts Institute of Technology, Boston, Mass.
*Moore, Herbert (1907), 99 South Front street, Memphis, Tenn.
Moore, Hervey M. (1907), United Iron Works Company, Springfield, Mo.
*Morgan, William Fellows (1905), Arch 5, Brooklyn Bridge, New York, N. Y.
Morris, O. J. (1905), Wilson building, Dallas, Tex.
Morse, Louis S. (1909), York Manufacturing Company, York, Pa.
*Morton, William P. (1907), Henry Bower Chemical Manufacturing Company, Philadelphia, Pa.
Neff, Peter (1904), 406 High street, Canton, Ohio.
Neubecker, Jean (1908), 347 East One Hundred and Thirty-ninth street, New York, N. Y.
*Nickerson, J. F. (1904), 431 South Dearborn street, Chicago, Ill.
Nordmeyer, L. C. (1904), 1214 Liggett Building, Eighth and Chestnut streets, St. Louis, Mo.
Nottberg, William (1905), 3415 St. John avenue, Kansas City, Mo.

Nulsen, Herbert S. (1909), 90 West street, New York, N. Y.
Odermann, E. H. (1905), Frick Company, Waynesboro, Pa.
Palmer, C. C. (1904), Railway & Stationary Refrigerating Company, 11 Pine street, New York, N. Y.
*Parsons, Charles H. (1907), 343 Bridge street, Springfield, Mass.
Parsons, W. Everett (1904), (Director 1905, President 1906), 818 Degraw avenue, Newark, N. J.
Patitz, G. J. (1909), Peter Schoenhofen Brewing Company, 526 West Eighteenth street, Chicago, Ill.
Penney, Edgar (1904), (Director 1905-'07, President 1908), Newburgh Ice Machine & Engine Company, Newburgh, N. Y.
§Phillips, E. A. (1911), Central Ice Co., Beach Haven, N. J.
Phillips, Ellis L. (1904), (Director 1905-'06), 50 Church street, New York, N. Y.
*Phillips, Louis A. (1909), Mitchell-Tappen Co., 149 Broadway, New York, N. Y.
Pilsbry, F. W. (1904), (Director 1907-'09), 1332 Monadnock building, Chicago, Ill.
Plock, John L. (1910), 30 Church street, New York, N. Y.
Pownall, H. D. (1907), Arctic Ice Machine Company, Canton, Ohio.
§Prell, John S. (1907), 1137 Geary street, San Francisco, Cal.
Pryor, Frederick L. (1911), Stevens Institute of Technology, Hoboken, N. J.
Qualtrough, B. F. (1911), 321 Reliance building, Kansas City, Mo.
*Quigley, James Edwin (1905), 466 South Rebecca street, Pittsburgh, Pa.
*Reid, Walter C. (1904), (Treasurer 1905-'11), 32 East Forty-second street, New York, N. Y.
*Reilly, James P. (1905), 17 Battery place, New York, N. Y.
Rey Basadre, J. S. (1906), 569 Avenida Quintana, Buenos Aires, Argentine Republic.
Richardson, George P. (1911), Isbell-Porter Company, 46 Bridge street, Newark, N. J.
*Richmond, Herbert (1911), 90 West street, New York, N. Y.
Riley, William H. (1908), Remington Machine Company, Wilmington, Del.
Robertson, G. A. (1907), Merchants' Ice & Cold Storage Company, Brook and Main streets, Louisville, Ky.
*Rodgers, Charles W. (1911), Independent Ice Company, Wilmington, N. C.
Roelker, H. B. (1904), (Vice-President 1905, Director 1906-'08), 41 Maiden lane, New York, N. Y.
§Roos, Frank J. (1906), Foote Bros. Gear & Machine Company, 214 North Carpenter street, Chicago, Ill.
*Rose, Clarence E. (1911), 500 East Sixth street, Little Rock, Ark.
Rosener, Leland S. (1910), 1129 Merchants' Exchange building, San Francisco, Cal.
*Ross, William H. (1904), (Secretary), 154 Nassau street, New York, N. Y.
Rowe, Samuel J. (1904), 233 East Main street, Waynesboro, Pa.
*Roy, L. A. (1911), Rector building, Chicago, Ill.
*Ruddick, John A. (1906), Dairy and Cold Storage Commissioner, Ottawa, Canada.

Ruemmeli, Albert (1909), (Vice-President 1911-'12), Ruemmeli-Dawley Manufacturing Company, 3900 Chouteau, St. Louis, Mo.
§Sandholt, Walter W. (1909), 3965 Wilda Vale avenue, Oakland, Cal.
Schadek, E. W. (1905), Ruemmeli-Dawley Manufacturing Company, 3900 Chouteau avenue, St. Louis, Mo.
Schmidt, Louis M. (1904), 84 West Main street, New Britain, Conn.
§Schulte, Charles F. (1911), 2723 Bennett court, St. Louis, Mo.
*Seigle, Joseph (1911), 417 East Court street, Cincinnati, Ohio.
*Serrill, Horace P. (1905), 411 North American street, Philadelphia, Pa.
*Sethman, George H. (1909), 647 Williams street, Denver, Col.
Shipley, Samuel J. (1904), 90 West street, New York, N. Y.
Shipley, Thomas (1904),(Director 1905-'11, President 1912, Director) York Manufacturing Company, York, Pa.
Shipley, William S. (1906), 90 West street, New York, N. Y.
*Smith, Guy B. (1907), 306 St. James place, Brooklyn, N. Y.
*Smith, Morgan B. (1911), 371 Atwater street, Detroit, Mich.
*Sparks, John C. (1906), 30 Church street, New York, N. Y.
Starr, John E. (1904), (President 1905, Vice-President 1906-'07, Director 1908), 90 West street, New York, N. Y.
*Stephens, Jr., L. H. (1907), St. Louis Refrigerating & Cold Storage Company, Lewis and O'Fallon streets, St. Louis, Mo.
Sterrett, A. W. (1909), Pacific Cold Storage Company, Tacoma, Wash.
*Stevenson, S. P. (1907), 1500 West Fourth street, Chester, Pa.
*Stockman, O. S. (1909), Armstrong Cork Company, Union Bank Building, Pittsburg, Pa.
*Stone, Junius H. (1906), Crown Cork & Seal Company, Palamos, Spain.
Stratton, Harrison D. (1908), 2610 Callowhill street, Philadelphia, Pa.
Strickler, A. B. (1906), York Manufacturing Company, York, Pa.
Tait, Roderick H. (1907), (President 1910), Liggett building, St. Louis, Mo.
Takahashi, Torata (1911), Teikoku Reizo Kabushiki Kwaisha, 12 Akashicho, Tsukiji, Tokyo, Japan.
Taylor, John R. (1907), 613 South Ervay street, Dallas, Tex.
Taylor, Walter A. (1907), P. O. Box 461, Hammond, La.
Thompson, Edgar W. (1905), Thompson & Gidley, P. O. Box, 260, Bombay, India.
Thompson, M. W. (1907), Greensboro, N. C.
*Tihotsky, Constantin (1911), 77 Sergierskay street, St. Petersburg, Russia.
*Tinker, Henry W. (1905), 41 Richmond street, Boston, Mass.
Torrance, Jr., Henry (1904), (Director 1905-'07, Vice-President), 50 Church street, New York, N. Y.
Trautwein, Alfred P. (1904), Carbondale Machine Company, Carbondale, Pa.
*Turner, Charles L. (1905), 411 North American street, Philadelphia, Pa.
Uchimura, Tatsujiro (1908), 10 Yariyacho, Kiobashiku, Tokyo, Japan.
Vesterdahl, Karl (1904), (Vice-President 1908-'09), 90 West street, New York, N. Y.
Vilter, Theodore O. (1908), (Director), 872 Clinton street, Milwaukee, Wis.
Vogt, Henry (1904), Henry Vogt Machine Company, Louisville, Ky.
Vollmann, Carl W. (1904), The Linde Canadian Refrigerating Company, 37 St. Peter street, Montreal, Can.

Von Weise, Louis B. (1911), 3003 North Broadway, St. Louis, Mo.
Voorhees, Gardner T. (1904), (Director 1910-'12), Engineers' Club, 32 West Fortieth street, New York, N. Y.
Voss, Bernhard (1904), 427 East One Hundred and Fortieth street, New York, N. Y.
Wait, John C. (1904), (Director 1908-'10), Woolworth building, New York, N. Y.
Waite, Nelson J. (1907), Sheriff Street Market & Storage Company, Cleveland, Ohio.
Walter, Bruce (1907), 6823 Thomas boulevard, Pittsburgh, Pa.
§Warner, Irving (1906), Charles Warner Company, Wilmington, Del.
*Webber, W. J. (1910), Cochrane Chemical Company, 40 Central street, Boston, Mass.
§Weddell, George O. (1911), York Manufacturing Company, York, Pa.
Wegemann, Karl (1904), (Director 1908-'10), Ice Cream Construction Company, 90 West street, New York, N. Y.
Wells, George E. (1911), Anheuser-Busch Brewing Association, St. Louis, Mo.
*Werliin, L. (1905), 2815 Gray's Ferry road, Philadelphia, Pa.
Whelan, Robert A. (1904), 5745 Wabash avenue, Chicago, Ill.
*Whittemore, Clinton L. (1911), 48 Gay building, Third and Pine streets, St. Louis, Mo.
*Whitten, William M. (1907), Armstrong Cork Company, 50 Church street, New York, N. Y.
*Widmann, F. (1906), Wainwright building, St. Louis, Mo.
Williams, E. T. (1911), Westerberg & Williams, Woolworth building, New York, N. Y.
Williams, Llewellyn (1904), (Director 1907-'09), United Fruit Company, 131 State street, Boston, Mass.
Winborg, Abel (1906), 428 Park street, York, Pa.
§Wittemann, Rudolph W. (1905), Wittemann Brothers, 41 Ferris street, Brooklyn, N. Y.
Wittenmeier, Fred (1910), 470 West Erie street, Chicago, Ill.
§Wolf, Carl B. (1906), 511 Denckla building, Eleventh and Market streets, Philadelphia, Pa.
Wolf, Fred W. (1904), 7341 North Ashland boulevard, Chicago, Ill.
Wolf, Otto C. (1904), 511 Denckla building, Eleventh and Market streets, Philadelphia, Pa.
Woodcock, Willard J. (1905), 13 Cambridge place, Brooklyn, N. Y.
Woods, Arthur R. T. (1905), The Red Cottage, West Hill, Harrow, Middlesex, England.
*Wright, George W. (1907), Baltimore Refrigerating & Heating Company, 426 South Eutaw street, Baltimore, Md.
Wuertenbaecher, John J. (1908), 3315 Russell avenue, St. Louis, Mo.
Young, Conrad H. (1906), Armstrong Cork Company, Union Bank building, Pittsburgh, Pa.

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* Associate Member. § Junior Member.
Names without reference marks are Members.
Figures in parentheses, as (1904), immediately following the name, denote year of admission.

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